Materials & Methods

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ENGINEERING

MAGAZINE

Should the Steel Industry Expand Now?

Eliminating Cracking in Magnesium Arc Welds

Materials of Work

Induction Heating for Steel Forging Can Reduce Costs

Application of Heat to Swaged Tungsten Permits Parts to Be Machined

Oxide Removal Important in Final Processing of Aluminum

Stainless Steel Paint Offers Corrosion Resistance, Hardness

Vulcanized Fibre Is Strong, Tough, Hard and Easy to Work

Quick Identification of Plastics

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MATERIALS & METHODS Manual (Section

APRIL 1948

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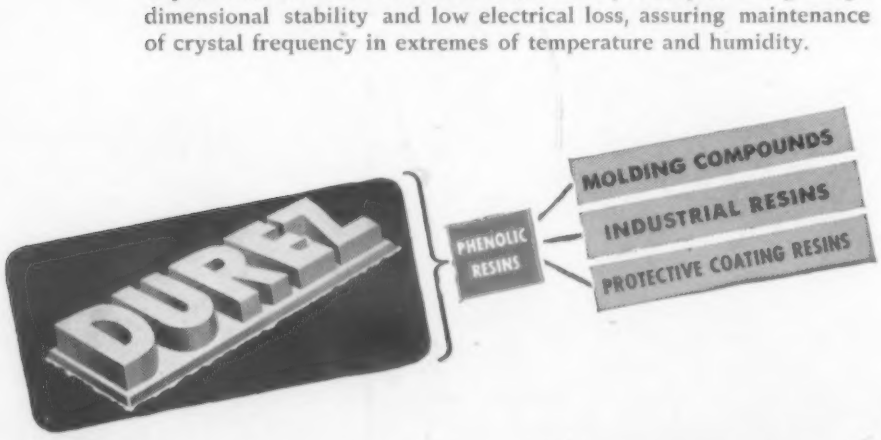

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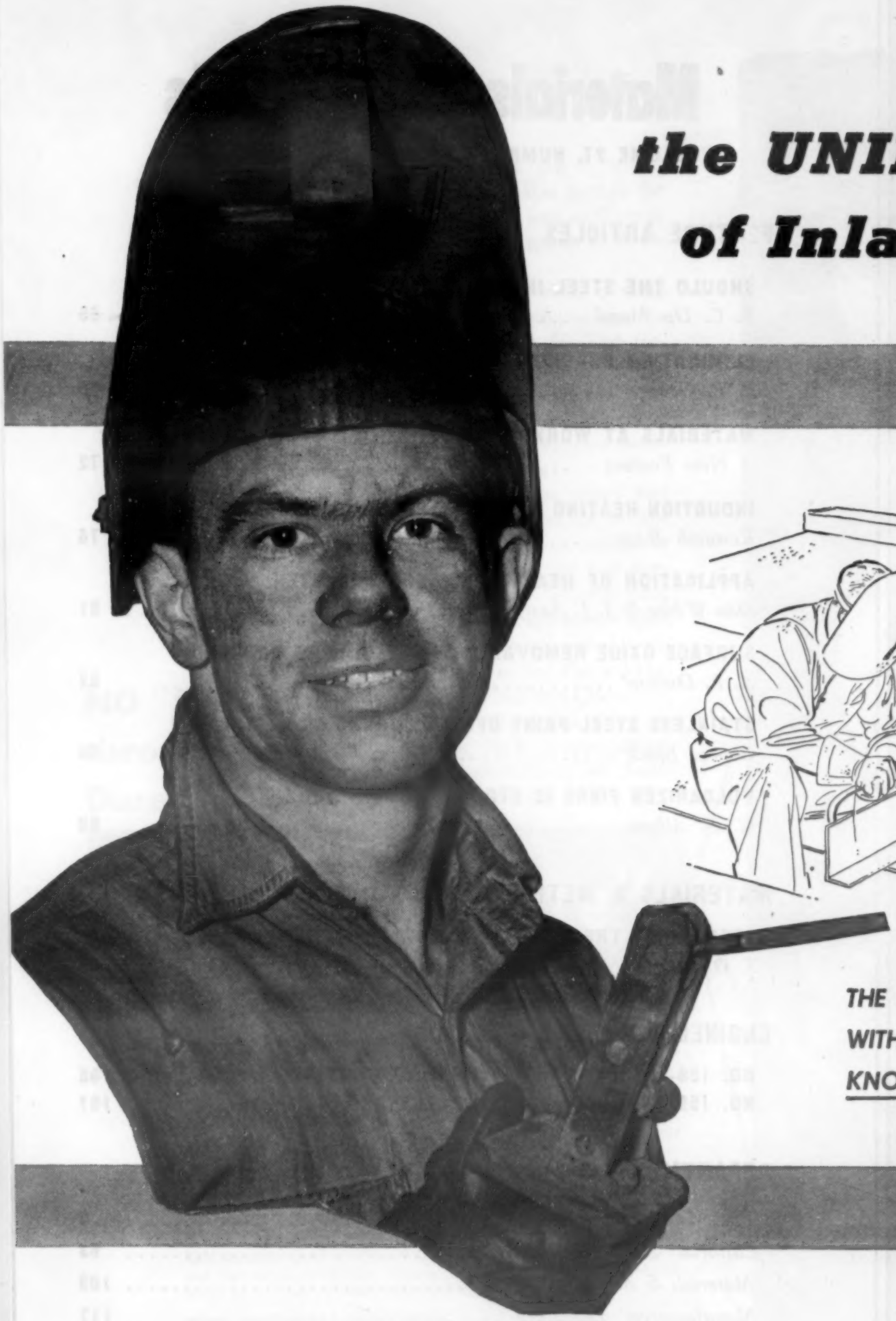

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The MATERIALS OUTLOOK...

UNITED STATES MINERAL SELF-SUFFICIENCY—According to a survey of the U. S. Bureau of Mines, the United States can become virtually self-sufficient in 21 minerals "if technologic and economic changes permit use of known sub-marginal resources". The minerals include coal, iron ore, petroleum, copper and aluminum ores. We are completely at the mercy of foreign sources for platinum, tin, industrial diamonds, quartz crystal and asbestos. For an additional 13 minerals, we are partially dependent on foreign sources. The survey asserts that we are exceptionally well supplied with coal, reasonably well off in iron ore, and potentially self-sufficient in petroleum.

•

STEEL AND ALUMINUM RELATIONSHIP—Any improvement in either the sheet steel or sheet aluminum supply situation will immediately be reflected in an easier supply of the other. For instance, either sheet steel or sheet aluminum could be used for a large majority of the 10,000 freight cars to be built each month. Aluminum hopper cars have proved successful, and at present 8,000-gal. aluminum tank cars are being built for one oil company. There probably will be more reshuffling of markets between aluminum and steel, but not to any great extent this year. Raw materials for aluminum are plentiful with the exception of power capacity. The major bottleneck is in ingot capacity and rolling equipment.

•

MAGNESIUM ON UPGRADE—Because both aluminum and steel are in short supply, there is an increase in the use of magnesium. A practical method of plating magnesium and use of magnesium sheet for aircraft skins forecast increased uses in little-explored fields. At present the magnesium supply is ample and should continue to be so even with a considerably heavier demand.

•

CADMIUM AMPLE, NOT OVERABUNDANT—For the first time in several years cadmium is in good supply, with demand and supply approximately balanced. Users won't be permitted to run wild in buying large supplies, since producers are trying to dole the supplies wisely. The government will stockpile any surplus which can meet its specifications. Government specs on cadmium are so stiff that little can be found to meet requirements.

•

EUROPEAN SCRAP—Observers hope that the reported 10,000,000 tons of steel scrap in Europe suitable for shipment to the United States is not another dream. If this quantity were to become available, our supply could be built up to a safe inventory. At the current rate, 10,000,000 tons of scrap is equivalent to two months' shipments of finished steel. Another effect could be a reduction in scrap prices and a lessening of pressure for any additional price rises in steel. A general easing of the scrap situation would probably release more pig iron for foundries, many of which are living from hand to mouth.

(Continued on page 4)

The Materials Outlook *(Continued)*

PLASTICS SUPPLIES—Polystyrene plastic consumption in 1947 was 37% greater than in the previous year. New production will more than double production by the end of 1948, bringing total production up to about 200 million pounds a year—250 times the production of 1939. Polystyrenes are attractive to industry because of their low cost, ease of molding and range of color possibilities. Phenolics still rank first in plastics used, but further expansion in production of phenolics will be hampered by a continuing shortage of phenol. Phenolics are being used in increasingly large quantities as binding and impregnating agents in laminates.

•

METAL FLAME-PROOFING AGENTS—Zirconium and titanium are coming to the fore as materials for flame-proofing fabrics. These two metallic elements are replacing antimony, which is scarce and the supply of which is often doubtful.

•

INDUSTRIAL DIAMONDS—The potential shortage in industrial diamonds such as are used for lapping, honing and grinding is more artificial than real. Government representatives have been dickering with the British. The difficulty is said to result from an international monopoly in industrial diamonds. Some officials feel that rather than give away all of our money in European relief we should buy such supplies as diamonds, even at inflated prices, to get something in return for our expenditures.

•

BEARING LUBRICANTS—One big equipment manufacturer is meeting with success in using molybdenum sulfide as a lubricant for bearings operated under heavy pressures and at high temperatures, which cause ordinary oils and greases to oxidize or gum. The molybdenum sulfide is produced by the company as a fine black powder, highly refined to remove silica, free sulfur and other impurities. The sulfide can be used suspended in a solvent, in a water emulsion or mixed with oil or grease.

•

LEAD SUPPLIES AND PRICES—The present 15¢ price for lead is admittedly an anomoly. According to statistics, the price cannot stay at this level, which is 50% above what statisticians give as the "adjusted economic level". However, under present conditions, it would be very much of a gamble to plan on any sudden drop. With a high per capita consumption and comparatively low production, the anticipated demand far exceeds visible supplies. The projected shortage will prevent the government from carrying out its stockpiling programs unless there should be a business slump. One lead industry representative feels that the 1948 supplies of lead may fall below that of 1947, because last year considerable hoarded scrap came into the open to help supplies generally.

•

GRAY IRON CASTINGS—Behind the gray iron castings shortage in many parts of the country is a chain of circumstances. Gray iron foundries have found it hard to get pig iron, and inventories are low. Freight has always been a major cost in pig iron, and at present pig is being hauled from wherever it can be obtained. The problem stems from the scrap shortage which causes steel mills to use more pig iron than is normal. The same is true with iron-pipe foundries. Any easing of the scrap situation should make pigs more freely obtainable and thus make gray iron castings less difficult to procure.

AN EDITORIAL

What is Materials Engineering?

If gardening is man's effort to improve his lot, what is materials engineering? Countless definitions have been proposed, for example that a materials engineer is the woebegone tailor who must fit the dream garment of the metallurgist to the awful reality of the design engineer.

This is inaccurate because it fails to emphasize one of the most important functions of materials engineering, which is solving fabrication and processing problems caused by the characteristically different working behavior of each material. In our opinion a more significant (also less frivolous) definition of materials engineering is this: *Materials engineering is the broad technical function of applying engineering materials to product manufacture.*

Sound materials engineering includes and correlates (1) applicability of materials in the finished product, (2) processing behavior (the workability, weldability, hardenability, machinability, etc.) of the materials to be used, and (3) best fabricating and processing methods for each material. Now materials-selection and materials-application decisions are an important phase of materials engineering. But these decisions are made only a few times in the life of a product. On the other hand, the problems of how best to process and fabricate the various materials involved in a production program are every-day, every-week problems that actually comprise the bulk of materials engineering activity.

We keep stressing this because there is an evident and old-fashioned tendency among top management in industry to think of materials engineering as simply deciding which materials to use, and not to give it credit for its real and complete contribution to solving the more numerous, more frequent and often more important materials problems originating in the plant. The materials men in a company—whether they're called materials engineers or metallurgists or process engineers or chief engineers or assistant something-or-other—are the ones who see that the methods and equipment for hardening alloy steels, welding aluminum alloys, drawing stainless, machining high strength cast irons, die casting magnesium, pressing brass powders, etc. are the best for the job, from the vital viewpoint of the material involved. If the processing doesn't work, *they* have to make it work—or change the material.

Many of the large and all of the best-managed product manufacturing companies now have regular "materials engineering" departments which employ from 2 to 50 engineers and metallurgists, each, on nothing but the processing and application problems of materials. These departments issue "materials standards books" or "materials and process manuals" which must be followed by designers and production men when making their own choices as to applications and processing of materials to be used.

But even when not so organized into centralized departments, the materials men throughout industry are carrying a great and active responsibility in both the product planning and the production areas. Their fellow engineers and manufacturing colleagues fully recognize the breadth and value of their contribution. It's time now for all their bosses to recognize it, too!

FRED P. PETERS

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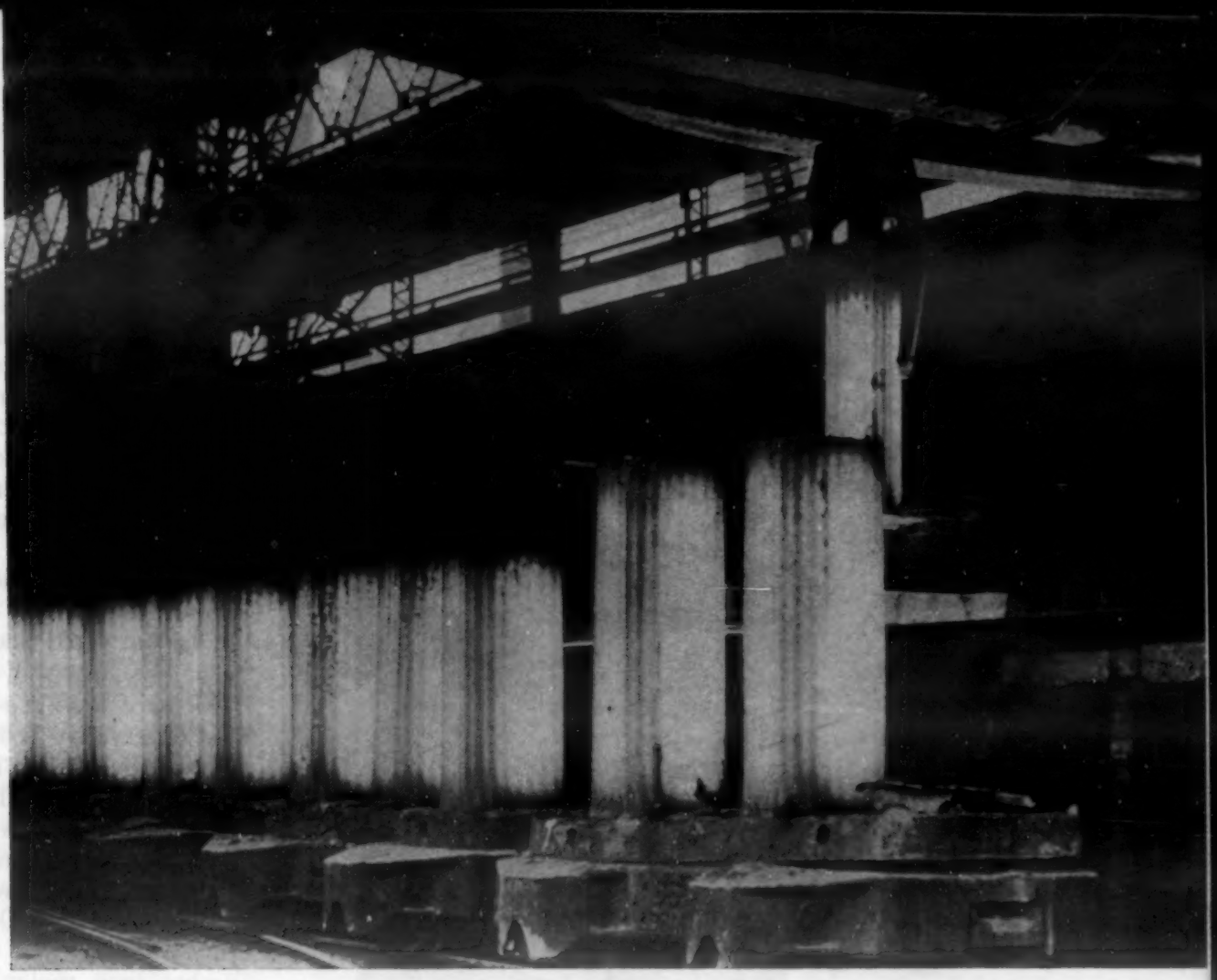


Steel producers are being urged to increase ingot capacity, but such an increase would only be a partial solution to the entire problem of the present steel situation. (Photo: Courtesy U. S. Steel Corp.)

Should the Steel Industry Expand Now?

by T. C. DU MOND, Managing Editor, MATERIALS & METHODS

FROM MANY SOURCES we hear demands that the steel industry expand promptly. How much expansion is sought depends upon who is doing the demanding. Figures tossed about rather lightly range from 10,000,000 to 30,000,000 ingot tons per year.

In many respects the question is academic, since considerable expansion has taken place during the last year and additional expansion is now under way.

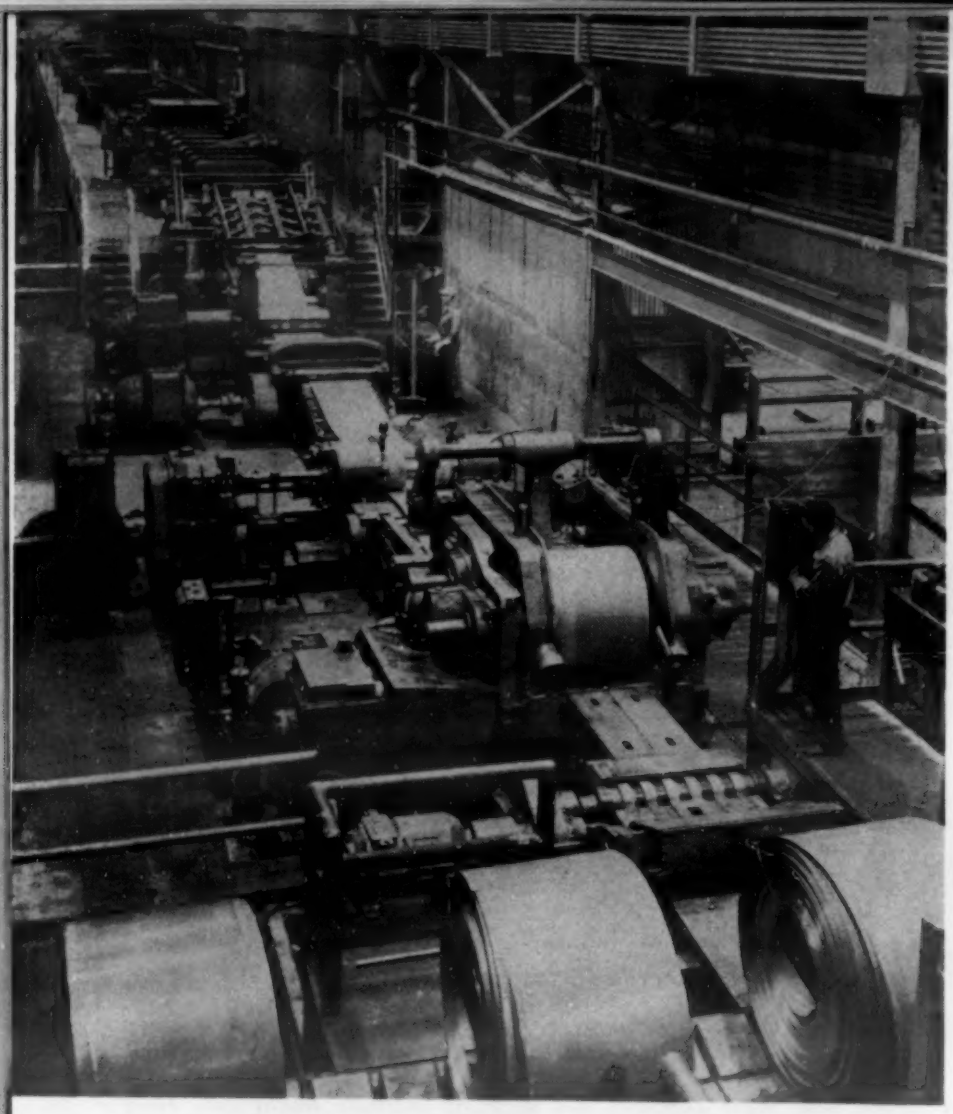
You as a consumer of steel have definite ideas on the steel shortage, but what would you do in view of the problems which now face the steel industry?

Despite the work done thus far, there is currently a market for a great deal more steel than is available or in sight.

This article will not attempt to answer the question of whether the steel industry should expand. Rather, it will attempt to point out to the users of steel the problems facing the steel industry in connection with any further expansion.

At the end of 1949 it is expected that the steel industry's capacity will be 96,418,460 ingot tons per year. If that figure is reached it will represent an increase of some 5 million tons over the capacity available Jan. 1, 1947. During 1947 capacity was increased by 2,992,210 ingot tons. Estimated ingot ton capacity increases are 1,011,000 in 1948 and 1,174,000 in 1949. Ingot ton capacity is somewhat misleading to the layman, for the actual usable steel coming from the steel mills is some 20 to 25% less than the ingot output. Considerable steel is lost in various operations through the mills.

Despite actual and projected capacity increases, the clamor still persists for more and more capacity.



Most steel companies have already spent vast sums to modernize present facilities. A few weeks ago Jones & Laughlin Steel Corp. publicly announced its new tin strip line, said to be the fastest in the world.

The most frequently heard figure is 10,000,000 ingot tons. How this figure was arrived at is hard to determine, but it has been repeated sufficiently often to have attained a semi-official respectability.

Although nearly every major industry now using steel feels that it could use more steel, there is a serious question as to just how much more actually could be used. Many plants, particularly in our heavily-industrialized mid-West, are loudly clamoring for more labor to help fabricate the steel they are now getting. If steel supplies were ample it is likely that the shortage of labor would still hold down output to below potential or desired levels.

If the steel industry generally were to expand rapidly, the steel users would be more severely pinched for supplies than they now are. Over 3,000,000 tons of steel would be needed to house and equip the industry for a 10,000,000 ingot ton capacity increase. Thus 3 million tons of badly needed steel would be withdrawn from the market.

Steel mills and foundries are having difficulty producing at present capacities because of an acute shortage of scrap. There are no visible signs at present to indicate any improvement in the scrap situation. All estimates of war-scrap to be returned to this country have proved false. It is likely to be the same with the 10 million tons of scrap recently reported to be in Germany. Either German industry will keep most of the scrap or some other country will snag a major portion of it.

Currently economists predict a depression, recession or levelling-off of business to come any time within a period ranging from a few months to a few years. If any of these predictions prove reasonably accurate, there is a strong possibility that the steel shortage will become a pleasant memory—at least from the viewpoint of steel producers.

The problems cited thus far are largely matters of opinion and probably could be debated endlessly without any positive answer evolving. However, there are many tangible problems upon which facts are certain.

Suppose the industry decided to expand much more than already planned. These are the questions to be answered and the facts to be considered:

Where Will the Money Come From?

Conservative cost figures show that an investment of well over $200 is required for every ton of added ingot capacity. The costs include buildings, furnaces, rolling mills and other equipment to produce and process the steel. If an additional 10 million net tons of capacity were to be provided a minimum outlay of $2,000,000,000 would be involved. The probability is that the cost would actually run much higher than the minimum figure mentioned.

It is obvious that steel companies, individually or collectively do not have 2 billion idle dollars lying around waiting to be invested in new capacity. A large portion of current income is needed to replace equipment that is constantly wearing out or becoming obsolete. Most industries today are experiencing great difficulty in raising new capital through new stock and bond issues. With taxes being what they are, it will probably be a long time before financing becomes a simple matter. Many companies have called off projected financing deals indefinitely. There is no reason to assume that steel companies would find financing any easier.

Where, then, will the money come from? Government funds would be the obvious answer, but most industrialists would shy away from this solution, even if the government were willing.

Where Should the New Capacity Be Built?

We haven't solved the financing problem, but let's pass over that detail. Suppose the money became available. Where are the furnaces and mills to be built? Because the high-grade ore deposits which have supplied this country for so long are to be exhausted in a matter of some 25 or 30 years, plant location becomes an important factor.

One ton of steel represents several tons of iron ore, scrap, coke, limestone and other ingredients. All of these materials are expensive to move, so the plant should be located centrally as far as raw materials are concerned. On the other hand, the mills should be close to their greatest markets to save freight charges on finished steels. It was consideration of the two listed factors which resulted in our present steel industry making its greatest investment in Pittsburgh, Chicago and other Great Lakes cities. More recently Baltimore and Birmingham have emerged as ideal producing centers.

When—and even before—the high-grade Mesabi ores are gone, other sources of ore must be found.

Low-grade lake region ores might be used; we might find it necessary to depend largely on South American or Labrador ores; Appalachian taconite ores might be the answer to one raw material source.

Then, how about coke? Where is the most economical location to bring ore and coke together? Some say the Eastern Seaboard or the Gulf Coast. Perhaps these will be the best locations. However, until something like a definite answer is found, where shall we build additional capacity?

How Will Other Materials Affect Steel Demands?

For a long time steel reigned supreme as an engineering material. It is still the most important material, but aluminum and magnesium—and plastics to a lesser extent—have begun to crowd steel out of some applications. The recent war gave impetus to this trend and the current steel shortage has made many consumers consider other materials for their normal products. As a matter of fact, so much aluminum is being used to replace steel that now sheet aluminum is scarce.

When all materials are easy to get some of the present defections will be offset by a return to the use of steel. Just as surely, though, many of the products will continue to use one of the newer materials. In the meantime other materials are coming along, such as ductile titanium metal, which will grab some portion of the materials market. How great an effect all these factors will have on the future demand for steel no one can predict with certainty.

Aside from competitive materials, there are new and better steels coming along which may have considerable influence over the types of steel making equipment necessary. Stainless steels are made in electric furnaces; carbon steels in open hearths. Too, a wide swing to the high-strength, low-alloy steels to replace carbon steels will automatically reduce the overall demand for steel tonnage-wise.

What Will Be the Effect of Inflated Steel Capacity During Times of Poor Business?

A study of the history of the steel industry will show that this is a feast or a famine business. Right now the feast is continuing. How severe will the fast become when war-induced shortages disappear? A frightening thought, from the producers' viewpoint, of a huge steel expansion program, is the spectre of idle plants and equipment during a period of retarded business.

Today—and probably tomorrow—the problem of inactive equipment is more serious than ever before. At one time, not too long ago, the steel industry could operate profitably when output was somewhere between 40 and 50% of capacity. Today the breakeven point is closer to 85% of capacity production. The breakeven point might drop somewhat during less prosperous times, but not sufficiently to avoid financial disaster if business drops off by as much as 25 or 30%.

Will the Trend Toward Consumer Owned Steel Mills Continue?

Recently many large users of steel have bought their own steel mills to insure a supply of steel for their own products. Such plant purchases could be indicative of a trend, but is it?

When business is good the captive steel mills will probably continue to operate economically. If business is poor these mills might be abandoned or closed-down. What, is likely to happen must be guessed with a fair degree of accuracy by those whose principal business is the making and selling of steel.

The foregoing problems are not all that face the steel industry. They do cover the most important points for which highly accurate answers must be found. There are a few elements in the overall picture which are more encouraging toward expansion, but with them too there are many question marks.

Here they are:

Will the Per Capita Use of Steel Continue to Rise?

The American Iron and Steel Institute estimates that at the start of last year (Jan. 1947) steel in use in the United States amounted to 14,500 tons for every man, woman and child in the country. This figure compares with 3,300 tons per person in 1900. Steel in use would, of course, include the steel in buildings, production equipment of all types, railroads and any other place or thing in which steel is used.

It is a matter of conjecture whether the increase in use of steel will continue. If it does continue will the rate be as great as during the last half-century? An answer here would be extremely helpful.

How Much Steel Will be Required to Fulfill Various Aid Commitments?

It is likely that the United States will be called upon to serve as the world's principal steel supplier for the next five to ten years. Advocates of aid programs claim that the steel to be exported in mill products and in fabricated machinery and equipment will have little effect on domestic supplies. Industry representatives are inclined to doubt the truth of those claims.

How long we ship steel and how much we ship depends largely on how fast the European nations recover. Perhaps there will be enough business in Europe, Asia and South America to justify expansion. However, if the steel industry is to expand it would like to know.

How Big Is the Replacement Market for Steel Already in Use?

With as much steel in use as there is today there is a vast replacement market. Estimates of the amount of steel going out of use each year due to corrosion alone range from $500,000,000 worth to as high as 3 billion dollars worth in the United States alone.

Increased use of stainless steels and other corrosion resistant materials should reduce the amount of replacement necessary. The questions remain: How long before the trend is reversed and how great will be the reduction?

As announced at the outset, this has not been an attempt to answer the important question of whether or not steel capacity should be increased. It was our sole aim to point out to steel users the problems facing the steel industry in general.

Important facts have been determined as to why cracking occurs when welding certain magnesium alloys. With these facts it is easy to select the proper alloy and alloy rod to produce serviceable welds.

Eliminating Cracking in Magnesium Arc Welds

by **P. F. GEORGE,** The Dow Chemical Co.

MAGNESIUM IS AN IMPORTANT METAL, not only because of its extreme lightness, good machinability and ease of fabrication, but because of the inexhaustible supply of magnesium from the sea. It is becoming more apparent that the cost of magnesium will compete with the cost of the other common metals on the volume basis when produced in large quantities. For these reasons research on magnesium alloys and especially magnesium fabrication processes, of which welding is gaining in importance, is of much significance.

Since the development of a practical method for the shielded arc welding of magnesium alloys, many improvements have been made that have improved the strength and corrosion resistance of the welds and have made possible the welding of all the commercial magnesium alloys. The purpose of this paper is to report the recent research work that has been done to make possible the welding of all the magnesium sheet alloys by the elimination of weld cracking.

Weld Cracking Observations

The ability to weld magnesium alloys with the shielded arc was the first real step in greatly reducing weld cracking over that encountered during gas welding, but occasionally cracking occurred where arc welds were made under highly restrained conditions.

Production welding showed that cracking was more pronounced in FS-1 alloy. Table I gives the compositions of the sheet magnesium alloys in the order of increasing cracking tendency. It can be seen from this table that, with the exception of the FS-1 alloy, the more aluminum and zinc that is present in the magnesium the greater the tendency for weld cracking.

Another important observation was made. The calcium, which was added to the M and FS-1 alloys to give good formability and rollability, was a factor in weld cracking. In all cases where cracking had occurred in FS-1 alloy, the calcium content of the metal was found to be high.

The location of the cracks in M alloy varied with different compositions of sheet and rod. For instance, an M alloy sheet welded with an M alloy rod would sometimes crack in the heat-affected zone and never in the weld metal, but if the M alloy sheet was welded with a rod containing aluminum and zinc, the cracking would occur in the weld metal although the cold strength of the weld metal had been increased by the use of the higher strength rod.

The causes and correction of these cracks became the object of this research.

It was first necessary to substantiate the observations made during production welding. To do this it was necssary to find a test which would produce a weld with severe restraint in order to exhibit cracking and at the same time be able to keep the welding conditions constant. A circle test piece, with slight modifications from that suggested by de Ridder for magnesium and aluminum was adopted.

These tests confirmed the observations made during production welding and showed the calcium content of M alloy, and especially FS-1 alloy, to be the largest single factor in weld cracking.

The next step was to find why these observations were true so the proper corrections could be made to prevent weld cracking. In order to find the cause of the cracking, metallographic examinations were made of the cracked areas in the heat-affected zone. These areas showed the presence of a network of a low melting constituent in the grain boundaries. As the alloy content increased this intergranular net-

A crack in the heat-affected zone of an M alloy sheet welded with an M alloy rod. (Magnification 4X)

Here the crack is in the weld metal when M alloy sheet was welded with J-1 alloy rod. (Magnification 4X)

work in the heat-affected zone became more pronounced. The cracked areas adjacent to the FS-1 alloy welds had a pronounced network of the low melting constituent at the grain boundaries.

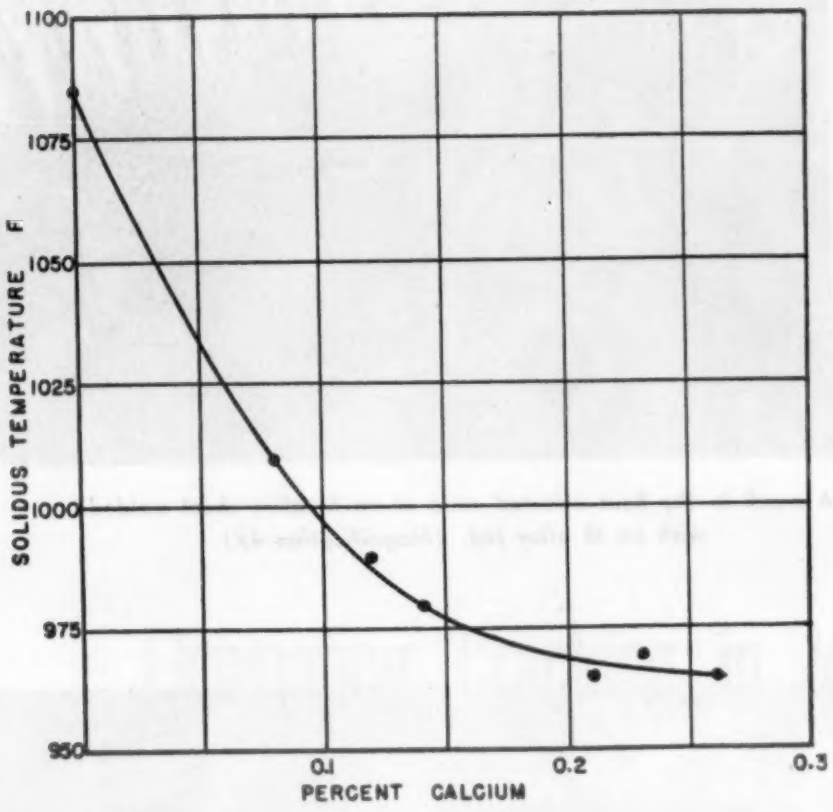
Examination of the structure near the cracks indicated that the width of the solidification range (the temperature difference between the liquidus and the solidus) of the alloy, which influenced the amount of the low melting constituent, should control the weld cracking tendency; but FS-1 alloy with a lower alloy content than JS-1 alloy had shown the most weld cracking. Since calcium had been shown by the circle test to have the greatest effect on the cracking tendency, it was decided to determine the nonequilibrium solidus of the FS-1 alloy with various amounts of calcium.

Small sheet samples of FS-1 alloy with calcium contents ranging from less than 0.01 to 0.26% were heated at various temperatures for 5 min., quenched in water and examined metallographically for the network of the low melting constituent. Data show that calcium lowers the solidus of FS-1 alloy to such a great extent that it can fall below the solidus of JS-1 and J-1 alloys. This lowering of the solidus below the other two alloys explains the FS-1 alloy having the greater weld cracking tendency.

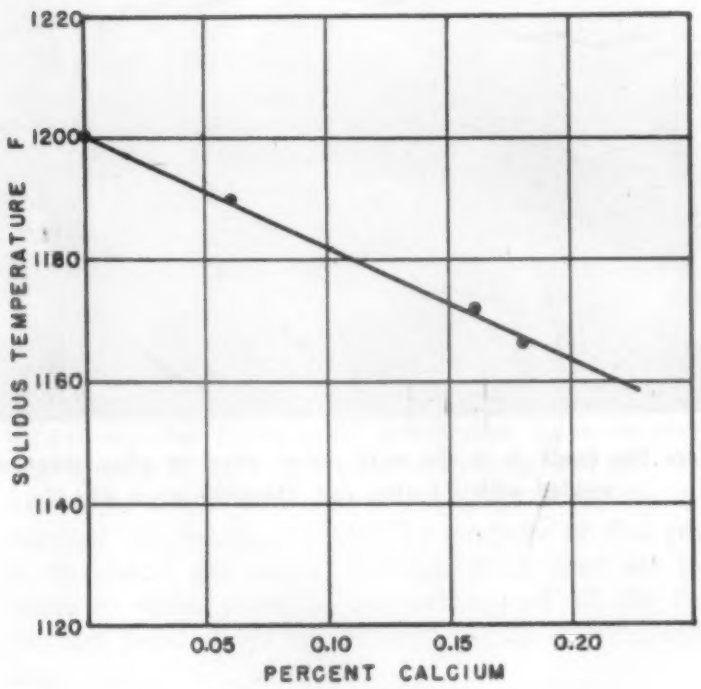
The same heating and quenching tests were run on M alloy to determine the nonequilibrium solidus of this alloy with various amounts of calcium. Here again the calcium lowers the solidus, although not as markedly as with the FS-1 alloy.

This study shows that the solidus, which determines the solidification range, can be obtained by microscopic examination of heat treated and quenched samples and that the weld cracking tendency of the base metal is largely dependent on the width of the solidification range. Table II shows the liquidus, solidus and approximate width of the solidification range of the magnesium sheet alloys, the order of which corresponds with the order of weld cracking tendency shown in Table I.

Another factor, which became evident in determining the tendency toward weld cracking, was the amount of shrinkage that occurred during the solidification and cooling of the welded metal. Table III shows shrinkage data taken from curves by Busk and Marande, which shows that the shrinkage is greater in the M alloy and is less in the higher aluminum- and zinc-containing alloys. Also, Sauerwald has shown that the shrinkage of alloys is



Nonequilibrium solidus of FS-1 alloy with various amounts of calcium.



Nonequilibrium solidus of M alloy with varying amounts of calcium.

smaller than that of pure metal, due to a certain expansion in the latter stages of solidification. Fortunately, the alloys with more aluminum and zinc have less shrinkage than M alloy, making the stresses less during the last stages of solidification at which time weld cracking may occur.

Practical Results

After the causes of the cracking were understood, it became easier to make corrections to eliminate weld cracking.

The weld cracking in M alloy was found, by the circle test, to be practically nonexistent if the calcium content was held below 0.15% and an M alloy rod was used. This became a practical solution because the forming and rolling properties of this alloy were good when the calcium content was held between 0.08 and 0.15%.

The location of the cracks varying with the composition of the rod when welding M alloy can easily be explained now that the cause of the cracking is understood. When M alloy sheet is welded with a rod containing aluminum and zinc, the weld metal would contain the cracks because the M alloy sheet would cool first, contract rapidly and cause high stresses in the aluminum- and zinc-containing weld metal before it has cooled down to the solidus temperature. The aluminum- and zinc-containing weld metal would then contain the network of the molten metal, which has no strength, and the stresses would pull it apart before it could completely solidify.

Cracking occurs in the heat-affected zone when M alloy sheet is welded with an M alloy rod, if the calcium content of the sheet is above 0.15%.

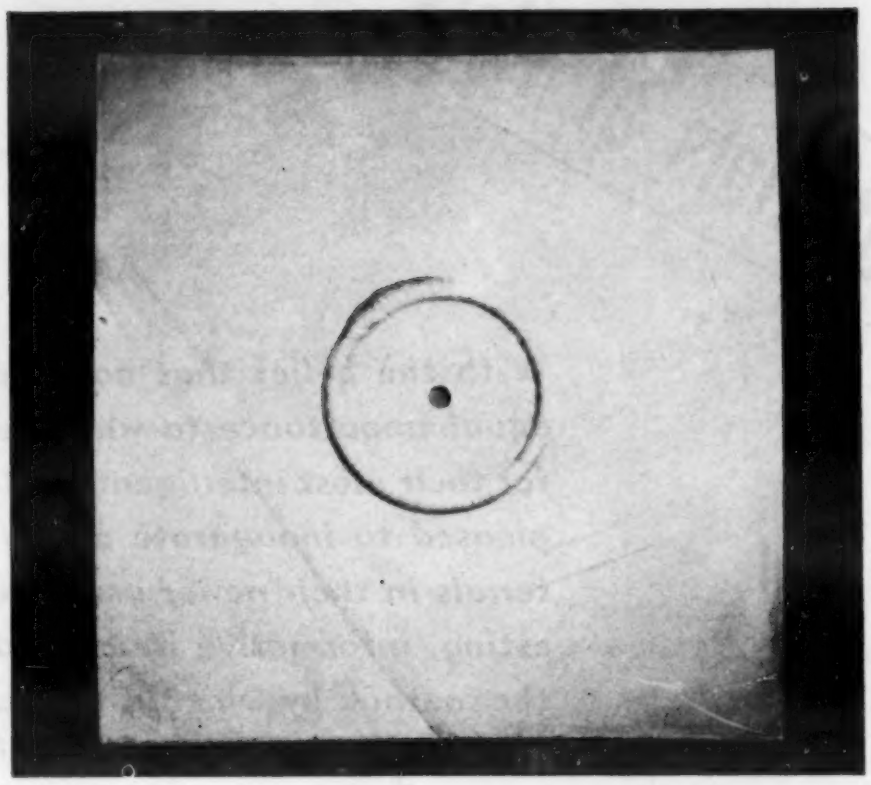
Keeping the calcium content low in the FS-1 alloy was not enough to completely eliminate weld cracking in restrained conditions. To eliminate the cracking in FS-1 alloy containing enough calcium to retain good forming and rolling properties, it was necessary to use a rod of a higher aluminum and zinc content than the FS-1 alloy. J-1, O-1 (magnesium, 8.5 aluminum, 0.5 zinc, 0.2 manganese), or C (magnesium, 9 aluminum, 2 zinc, 0.1 manganese) alloy welding rods gave good welds with little or no cracking even in highly restrained conditions. These lower melting point rods remain molten while the FS-1 base metal becomes completely solidified so that no stresses are built up in the heat-affected zone until after complete solidification has taken place in this area. This progressive solidification from the sheet to the center of the weld eliminates the cracking.

Table I—Magnesium Sheet Alloys in Order of Increasing Weld Cracking Tendency

Dowmetal Alloy	Composition, Balance Magnesium		
	Aluminum	Manganese	Zinc
M	—	1.5	—
JS-1	4.8	0.2	0.9
J-1	6.5	0.2	1.0
FS-1	3.0	0.3	1.0

Table II—Approximate Width of Solidification Range of the Magnesium Sheet Alloys

Dowmetal Alloy	Liquidus, F	Non-Equilibrium Solidus, F	Solidification Range, F
M 0.1% Ca	1200	1182	18
JS-1	1160	1050	110
J-1	1135	1000	135
FS-1 0.15% Ca	1170	980	190



Test panels were made with circular welds such as in this sample.

Using this same reasoning it might be assumed that M alloy could be welded with a higher alloy rod. This is true, but when M alloy is welded with rods containing more aluminum and zinc, cracks will usually occur in the weld metal of highly restrained welds because of the greater difference between their solidification temperature and the greater shrinkage of the M alloy, as previously explained.

No corrective measures were found necessary for welding JS-1 and J-1 magnesium sheet alloys using a rod of the same composition as the sheet. These alloys have a narrower solidification range than the FS-1 with calcium and also a lower shrinkage value.

Summary

1. A correlation between the width of the solidification range and the tendency toward weld cracking has been shown.

2. Metallographic methods of finding the nonequilibrium solidus is an easy means of determining the tendency toward weld cracking.

3. Calcium decreases the solidus to a remarkable extent in FS-1 alloy and somewhat in M alloy, therefore increasing the width of the solidification range and increasing weld cracking.

4. Weld cracking is eliminated in M alloy by keeping the calcium content below 0.15% and using an M alloy rod.

5. Weld cracking can be eliminated in FS-1 alloy by using a welding rod of J-1, O-1 or C alloy.

6. Weld cracking is not serious in FS-1 or J-1 alloys because the solidification range is less than FS-1 and they also have a smaller shrinkage in the solidification range.

Table III—Free Contraction in Sand Mold of Bar 48 In. Long, In. per In.

Dowmetal Alloy	Shrinkage In. per In.
M	0.0154
FS-1	0.0138
JS-1	0.0129
J-1	0.0117

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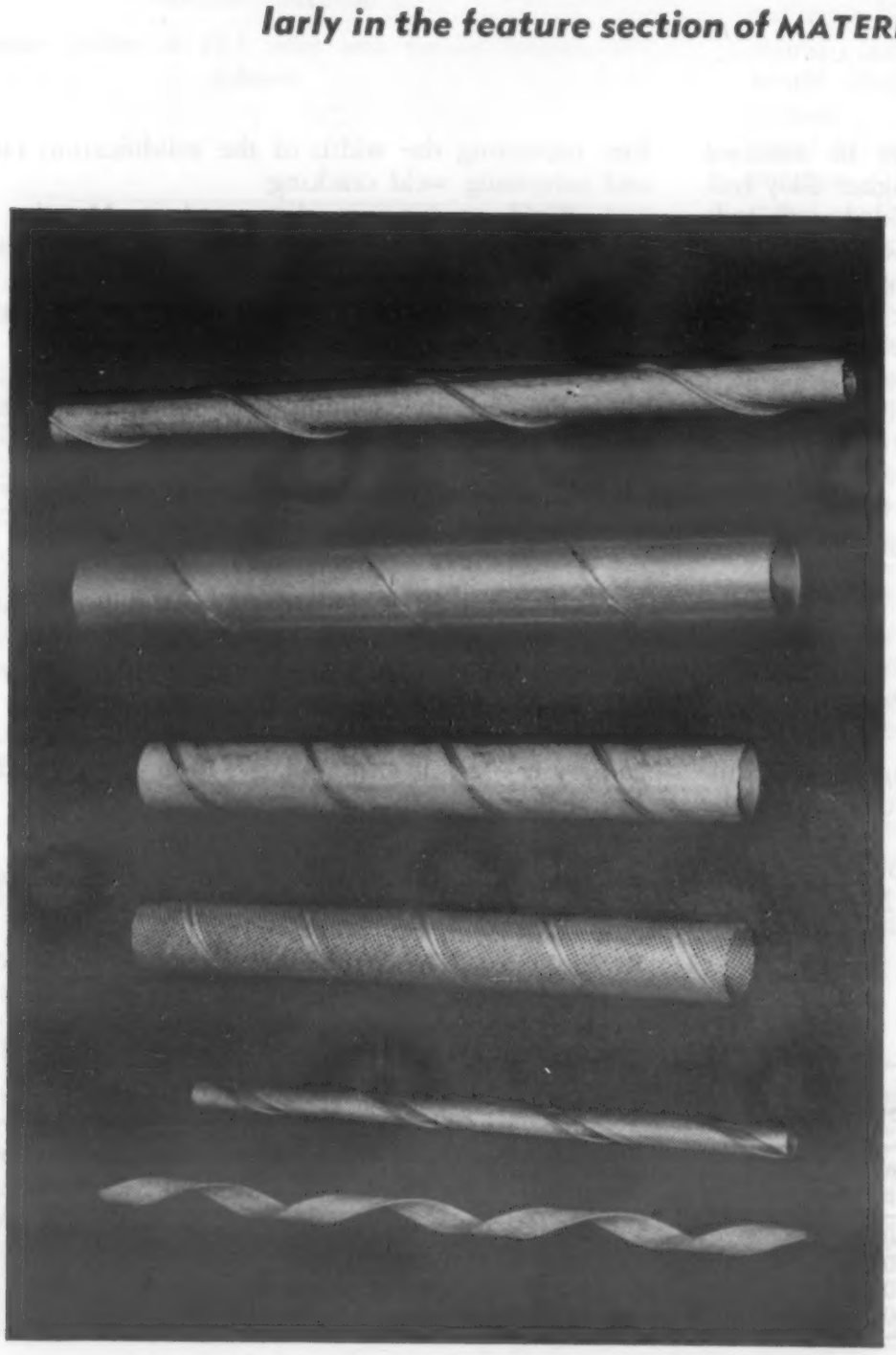
Materials at Work

With the belief that how materials are used is of equal importance to why they are used as a basis for their most intelligent application, the editors are pleased to inaugurate a new feature showing materials in their newer uses. Here you will find interesting, informative items and illustrations showing the method by which progressive engineers are taking advantage of the properties of materials—both new and old. "Materials at Work" will appear regularly in the feature section of MATERIALS & METHODS.



ALLOY TUBING

Aluminum, brass, copper, carbon steel, nickel, clad steels, Monel, in fact any metal or alloy which can be made in strip form can be made into a new type of tubing known as Spiralock. The name derives from the method of manufacture which involves spiral-forming and then locking the edges. This type of tubing is said to have greater structural strength than conventional tubing of equal wall thickness, being resistant to both bending and crushing loads.

Tubing of this type is made in sizes down to 3/16-in. o.d., depending on the type of locking joint. From these small diameters sizes can go up to 6 in. or larger, with wall thicknesses as light as ten-thousandths of an in.

The tubing is recommended for all service suited to the material employed, except that it is not recommended for handling gases and liquids under pressure, and in applications where bending is necessary.

In the accompanying illustration can be seen perforated, spiral-finned, open-spiral and other special forms of tubing.

CAST IRON WELDED TO SHEET STEEL

In making the guide vane assembly for mine ventilating units, the Jeffrey Mfg. Co. combines 15 cast iron vanes and inner and outer rings of heavy gage sheet steel. The vanes are welded to the inner and outer rings by means of 5/32-in. Ni-Rod electrodes. In the close-up illustration weld detail is readily seen. One bead around each end of the vane is sufficient to bond completely the vane and the ring. Blowers of this type range from 4 to 10 ft. in dia. and have capacities of from 15,000 to 500,000 cu. ft. of air per min.

STAINLESS STEEL HELICOPTER BLADES

Successful operation of helicopters in all types of weather is expected with the development of a new stainless-steel rotary wing by Goodyear Aircraft Corp. A flexible tube at the rotor head carries hot air to the root of the blade and along the leading edge. This design is expected to prevent the formation of ice while the aircraft is being operated in icing conditions.

The leading edge of this rotary airfoil is 0.030-in. stretched stainless steel with no seams or splices. Support is furnished by two spanwise spars spotwelded to the skin. The combination of stretched and spotwelded stainless steel is said to provide high resistance to fatigue and close control of airfoil contour.

Construction behind the main spar is a cyclewelded "sandwich" of Formica between two sheets of 0.0015-in. stainless steel. Although extremely light in weight, the metal blade presents maximum resistance to distortion under load, helping to provide more weight lifting power to the aircraft.

SOUND-DEADENING METAL

In a newly remodeled public telephone center, Rigidized metal is used to deaden sound in phone booths. For this service, flat sheets and coils of metal are first perforated with a fine mesh of small holes, spaced uniformly in all directions. The metal is then "Rigidized" with a special pattern which coincides with a high percentage of the perforations. The patterns and perforations create a series of perforated deflections and projections in the surface of the sheet. The combination results in high sound absorption and reduces the surface area from which sound can be deflected. Rigid-Tex Corp. technicians are experimenting with various combinations of perforations, patterns and metals to learn which gives the greatest sound absorption.

RHODIUM-PLATED ALUMINUM

In producing a new hearing aid, Sonotone Corp., Elmsford, N. Y., attained light weight and attractiveness by using a rhodium-plated, die cast aluminum front. In plating, the die casting was first buffed with a greaseless compound and then dipped into an aluminum cleaner. Next, the part was immersed into an Alumon solution, which resulted in a thin zinc film over the aluminum base. On top of this, alternate platings of copper and nickel are placed, with the final plating of rhodium being deposited on nickel.

ROUGHING UP CASTINGS

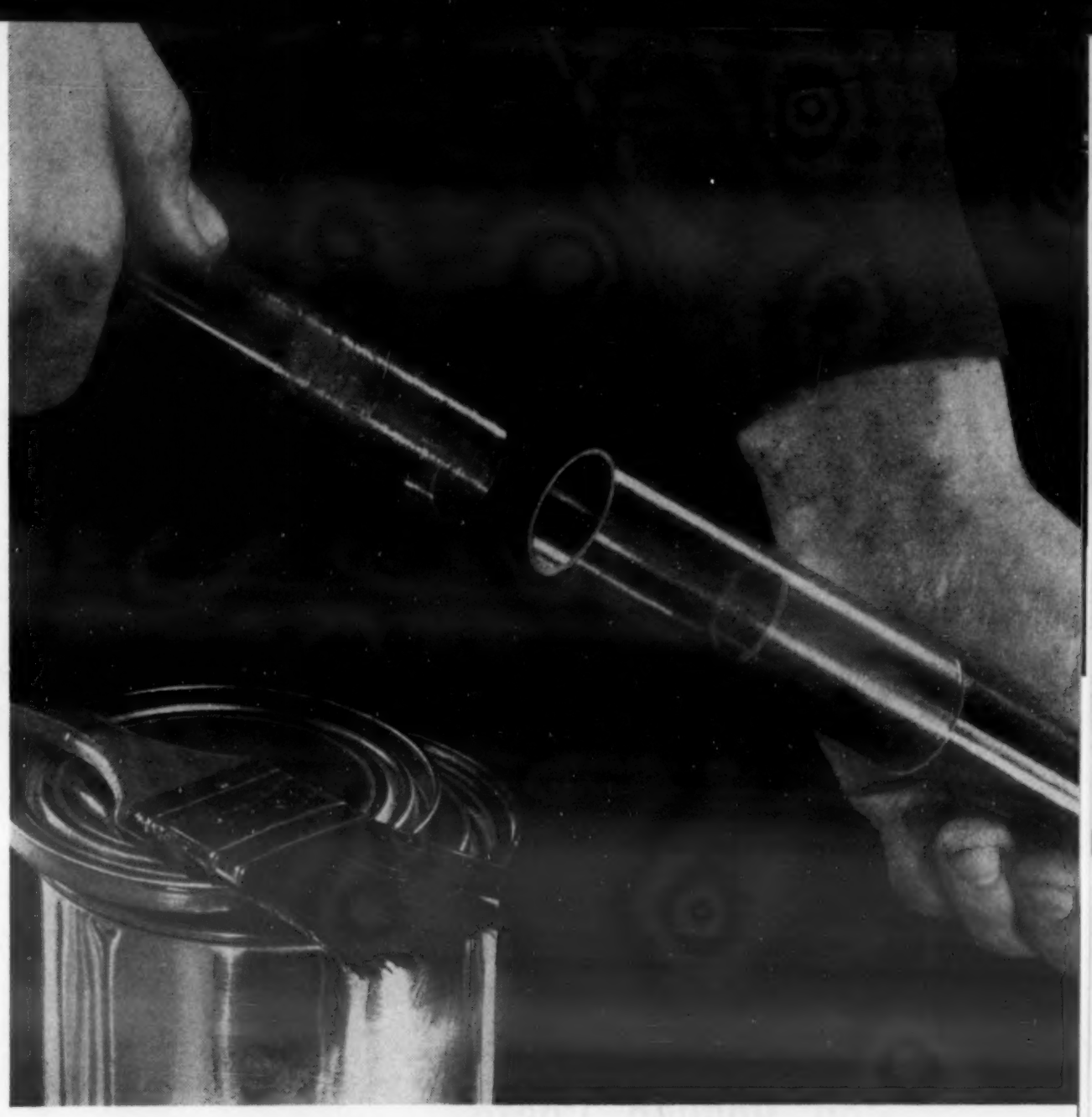
An aluminum cylinder has been used to replace one of cast iron in heavy-duty air brakes. Cylinders of this type are manufactured to extremely close tolerances. However, when aluminum cylinders were first used it was found that interior surfaces were too smooth to hold lubricating fluids. Several methods of roughening the interior surfaces were tried, but the 3½-in. inside dia. of the cylinders made the problem difficult. Now roughening is being done satisfactorily with a 3¾-in. dia. wire brush, made up of 0.0095-in. wire, operating at 2,000 rpm. from a floor stand machine. The cylinders are treated after brushing to prevent corrosion. The brushing does not disturb the close tolerances. Osborn Mfg. Co. engineers developed the technique.

PLASTIC GAS PIPES

In some installations being made by Southern California Gas Co., extruded Tenite tubing is being used instead of steel pipe. The plastic has had sufficient testing to give company officials assurance that it is capable of serving to conduct gas from the main to customers' meters. The Tenite pipe is being used generally except where it might come in contact with refinery gases and other products of oil refining. Rocky soil also is avoided.

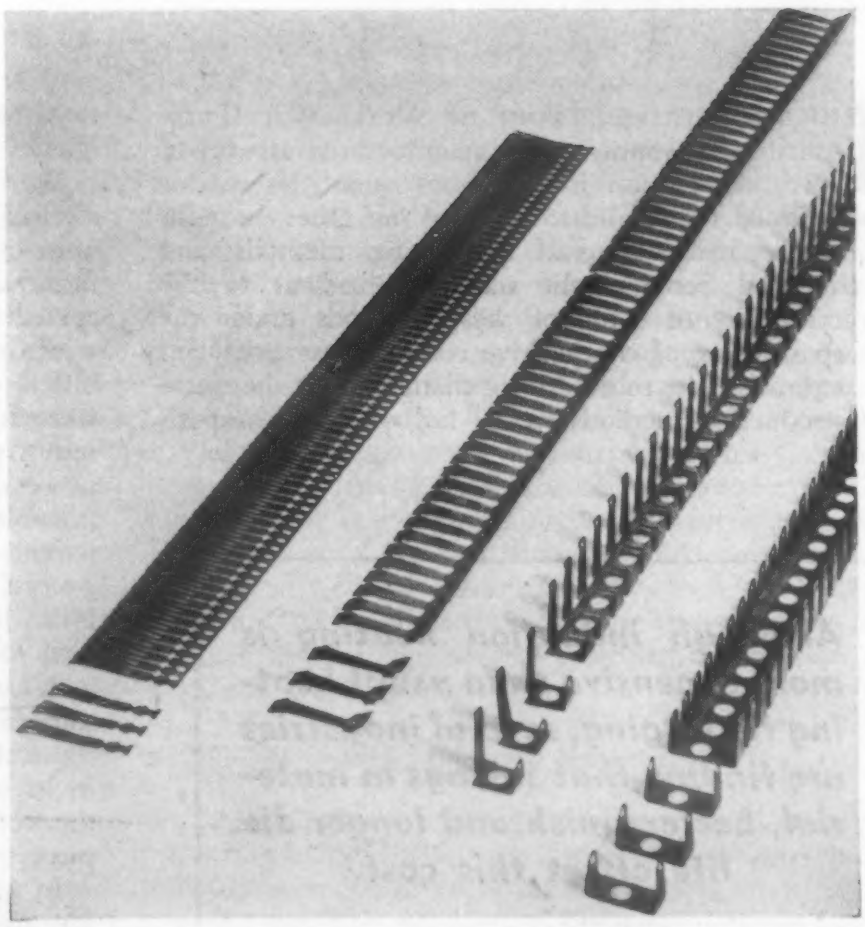
Joining of the piping is simple. If 1-in. o.d. piping is used, its ends are coated with a solvent cement and joined. Then a section of 1-in. i.d. tube is coated similarly on the inside and slipped over the joint. Readily available fittings are used to join plastic piping to the main and to copper tubing at the "riser" in the house. The tubing used for gas service is designed to withstand pressure of 30 psi.

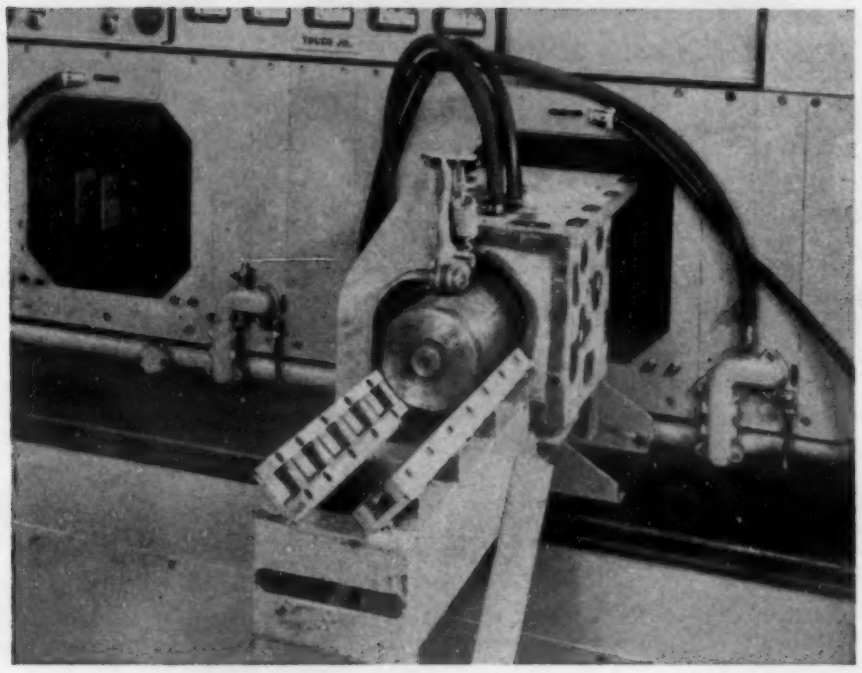
More than 500 installations, using 40,000 ft. of tubing, have already been made.



FORMED SPRINGS BY THE STRIP

A new idea in beryllium copper spring manufacture simplifies manufacturing operations and results in greater uniformity from spring-to-spring. As carried on by Instrument Specialties Co., parts are separated by a score line in continuous strips of from 12 to 16 in. in length. The bond between parts is sufficient to keep the lengths intact during heat treatment, plating and other processing steps as well as during shipment. Individual parts are then broken off from the strip for use. Shown here are a few types of springs so designed and handled.





One important advantage of induction heating in the forging of small parts is the ease with which the operation can be made semi-automatic. (All photos courtesy Tocco Div., Ohio Crankshaft Co.)

Induction Heating for Steel Forging Can Reduce Costs

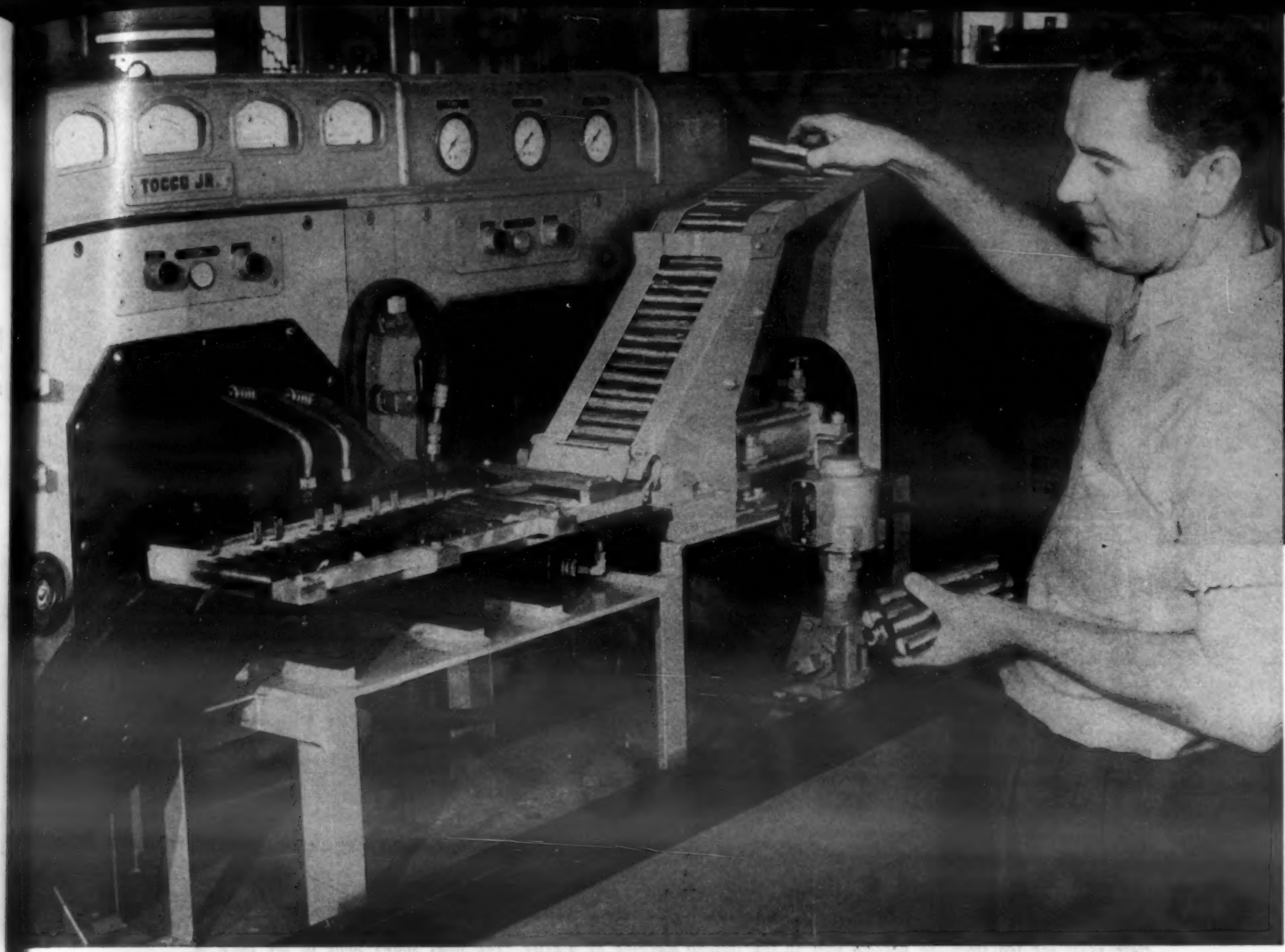
by **KENNETH ROSE**, Engineering Editor, Materials & Methods

THE PRODUCTIVE EFFORT of World War II, requiring the supplying of manufactured articles of every description in enormous quantities to our own armed forces and to those of our allies, brought into use many unusual processing methods and techniques. Some doubt was expressed as to the practicability of some of these methods under the sharp scrutiny of competitive costs. It was predicted that some of the more drastic changes from the norm of production methods would fail to meet competition when emphasis was once again placed upon obtaining given results at the lowest possible cost.

Although induction heating is more expensive than usual heating for forging, several industries are finding that savings in material, better finish and longer die life offset this cost.

War production demanded many parts of forged steel. Expansion of plant capacity and speeding of rates of production could be accomplished by use of induction heating for forging, and the method received a considerable impetus, especially in the widening of its scope to include heating of large billets. Many of the projectiles in the larger sizes were forged with the aid of induction heating, and industry acquired much valuable knowledge of the process, its limitations, and of the corollary savings possible through its use. The most immediately apparent result was the streamlining of the forging process so as to lift the billet, cut quite close to the finish-forged weight, from the belt or rack, cold, heat to forging temperature in a matter of seconds, and forge, in upset or other machines, in successive stations, without reheating. The quick heating reduced the scaling losses so considerably that some new lows in metal losses, representing the difference between the weight of the billet and the weight of the finished piece, were made possible.

In spite of the success of induction heating for forging during the war, many engineers were skepti-



Although heating costs in using induction heating for forging run up to one-third more than usual heating methods, these costs can be offset by savings in materials and in forging.

cal of its chances of survival in competition with other heating methods when results were again judged costwise. Induction heating is expensive heating. It had won a place for itself in certain types of melting, especially when high-grade steels were being melted. For heat treating, induction heating could offer lessened distortion and practically scale-free work, in addition to localized heating of otherwise inaccessible surfaces. Forging did not seem to offer the opportunities for savings necessary to offset its admittedly higher cost.

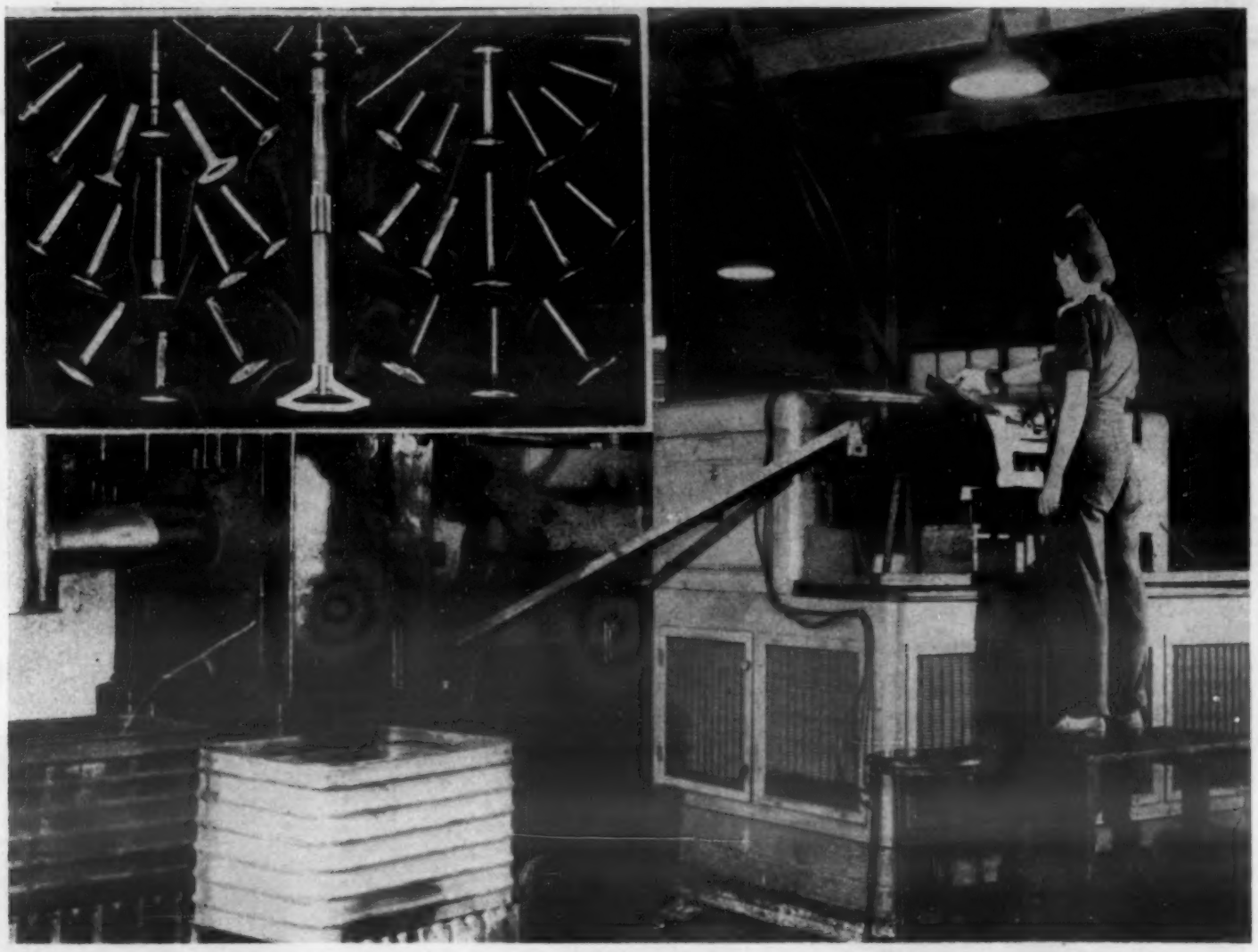
Considerable time has elapsed since the end of hostilities, and industry has approached normal conditions closely enough to permit judging the merits of induction heating for forging under peacetime conditions. The facts cannot yet be reduced to dollars and cents as definitely as might be desired, but a relative cost picture can be obtained in spite of the instability of many, indeed most, of the elements.

There seems to be no question about the higher cost of heating of steel when done by induction. One large forge shop using both methods, and keeping careful records of costs, estimates that induction heating is about ⅓ more expensive than heating in oil-fired furnaces. This is an estimated average of many different jobs, and is figured for the heating alone, without regard to forging costs, or to other savings.

Despite these higher heating costs, induction heating has definitely won a place for itself in the forge shop. Oldsmobile Division of General Motors Corp., which utilized induction heating to a large extent in its forge shop for war work, has retained all of the induction equipment it used during the war, and has added much new equipment of the same type, all now converted to production of its peacetime product. The forge shop at International Harvester Co.'s new plant at Louisville makes use of the induction heating and of the conventional fired furnaces side by side. Other forge shops that had made use of this kind of electrical heating before the war, such as Timken-Detroit Axle Co., have kept it in service during and since the war, and several projected forge shops are planning installations.

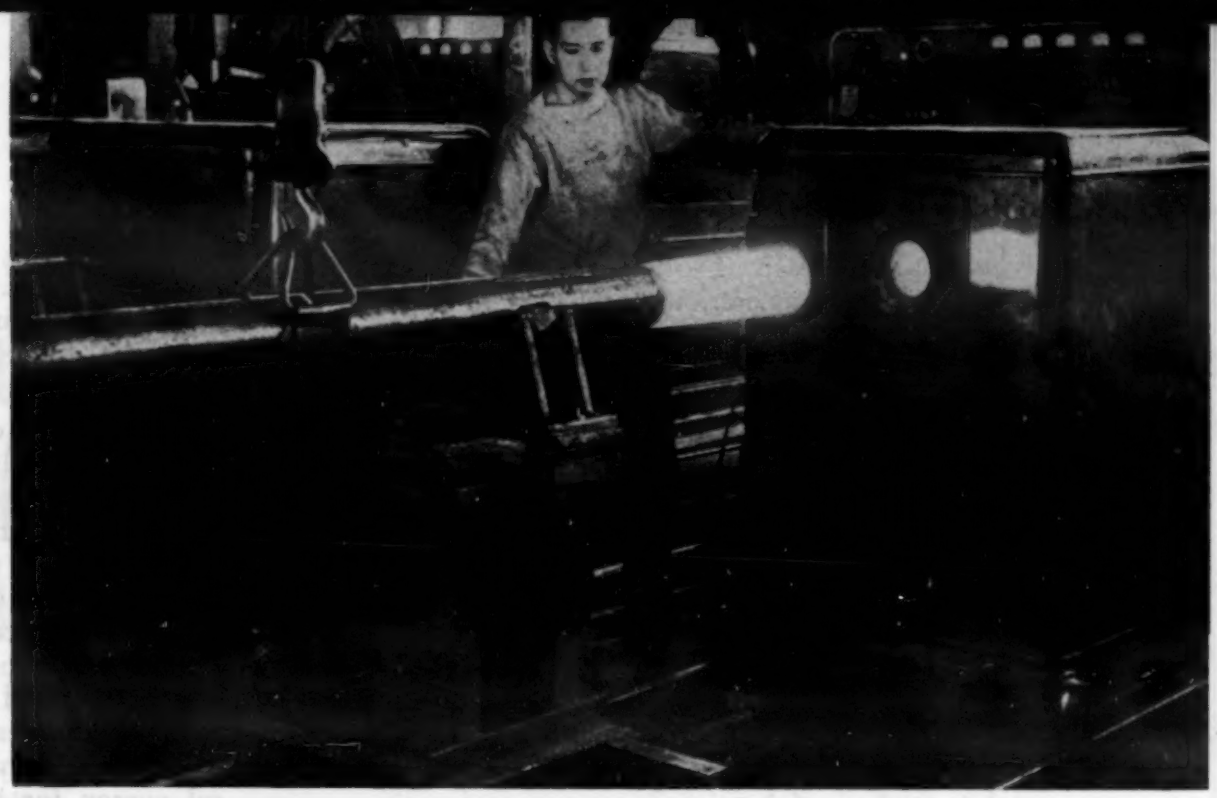
Efficient Use of Equipment Necessary

An important point in keeping costs of induction heating at the lowest possible level is efficient use of equipment. There are many different types of induction heaters on the market, but a few general princi-



Here parts are fed from the heating unit to the forging machine by gravity. The inset shows some of the parts so forged.

During the war, induction heating was used extensively in connection with such jobs as forging portions of aircraft propellers.



Steel rounds up to 5-in. dia. are successfully being heated for forging by induction methods.

ples are of value in the selection and operation of any type.

(1) *For through heating, as for forging, 10,000 to 12,000 cycles is a good maximum frequency for 95% of the work.* Higher frequencies tend to accentuate the "skin effect," valuable in some types of heat treating, but decidedly undesirable in the forging of steel. One large manufacturer of induction heating equipment gives the following limitations for frequencies:

960 cycles—not economical for work smaller than 2¼-in. dia.
3000 cycles not economical for work smaller than 1-in. dia.
9600 cycles not economical for work smaller than ½-in. dia.

(2) *Coupling should be as close as possible.* A designer of equipment says that he tries to get coupling with 0.002 to 0.003 in., but a shop superintendent using the process believes 3/16 in. is a good working maximum. The same superintendent, in one of the large axle plants, declares that the apparatus isn't much good when the air gap exceeds ¼ in.

(3) *The rate and method of heating should be properly adapted to the work.* Supplying the proper power input is fundamental here, but correct design of the coil is also important, especially if the billet is different from the usual cylindrical form. When the shape of the billet is such that the energy input must be unevenly distributed, the turns in the coil can be so spaced as to bring more of them near that part of the work surface to receive the most heat.

The metallurgy of the steel is of importance but not to the same extent as in heat treating. For small parts the energy input is usually concerned only with the ability of the steel to heat uniformly. About 400 kw.-hr. are required to heat one ton of steel to forging temperature, about 2000 F, by induction heating, while in an oil-fired furnace temperature of the steel can be raised the same amount by burning 60 gal. of oil. At 1¢ per kw.-hr., the cost by the electrical method would be $4.00 per ton, while the oil furnace would accomplish the same result for about $2.25. This indicates the differential in heating costs that must be offset by other savings if induction heating is to be competitive.

Another cost study made at Oldsmobile Division of General Motors Corp. is even clearer in its comparison because costs for heating the same parts by both methods were available. Connecting rods and ring gears, pinions, and other small parts are heated by induction for forging, using 1920 cycles per sec. The connecting rods, of A1335 steel, in 1½-in. round, are heated in 56 sec., and die forged in four steps, with final trim. With the oil-fired slot furnaces formerly used, heating costs were 2½ to 3¢ for each piece, while the present induction heaters do the work for 4 to 4¼¢ per piece. Overall forging costs are slightly lower with the present heating, however, company engineers say.

Inasmuch as it is generally conceded that induction heating of steel for forging is more expensive than heating in fired furnaces, it is well worth while to examine the auxiliary savings that must offset this higher heating cost. These are the items that must be studied in any projected induction heating installation to determine if they will be sufficiently high to counterbalance the heating cost. They are:

1—Greatly decreased scaling.
  (a) Reduced cleaning costs.
  (b) Closer tolerances in the work.
  (c) Longer die life.
2—More readily adapted to automatic operation.
  (a) Can be fitted into conveyorized production.
3—Saves start-up costs.
4—Less floor space required.
5—Improved working conditions.
6—Saves costs during down-time.
7—Quicker heating.
8—More accurate control of temperature in work.
9—Heating can be localized.

Probably the advantage most frequently thought of in connection with induction heating is the practical elimination of steel scaling. Steel heated to forging temperature in fired furnaces will lose from 2 to 6% of its weight as scale. If the cost of the steel be assumed at $80 per ton, the steel so lost would be worth $1.60 to $4.80 per ton. The higher-priced alloy steels would make possible proportionately greater savings.

Longer die life is a real factor attested to by forge shop foremen, but it is almost impossible to reduce

it to a cash basis. The abrading effect of the scale is one of the deleterious influences in die life, and any reduction in its amount is helpful.

With the practical elimination of scale, the piece can be forged to closer tolerances. The chief benefits of such forging are felt after the work leaves the forge shop, and are difficult to estimate. Another saving in material derives from these closer tolerances, however, and it is of considerable importance cost-wise. Die forging requires that an allowance be made for flash, and this allowance, varying from about 12 to 25% of the weight of the billet, represents a $9.60 to $20.00 loss based upon $80 per ton for steel. Use of induction heating does not eliminate flash, but closer tolerances will materially reduce its amount, and the saving can properly be credited to that method of heating.

Helps Make Process Automatic

There is a strong trend throughout the manufacturing industries toward automatic processes. This has been emphasized by the recent large wage increases in most industries, placing a premium upon all kinds of labor-saving machinery. Induction heating equipment can be, and usually is, fitted with automatic timers, and so can be made to heat the work to a predetermined temperature through controls built into the apparatus. As there is no heat in the equipment, or in the work, until it is generated in the work itself, induction heating can be used in connection with conveyorizing without great difficulty. The entire heating and forging operation can frequently be made an automatic process by combining the automatic heating, conveyorizing, and machine forging. Most forging operations using induction heating are at least semiautomatic.

With fired furnaces it is necessary to have several men come to the plant a few hours before beginning plantwide operations, start the fires, and bring the furnace up to temperature. When the plant is operating on a 24-hr., 7-day basis this start-up problem disappears, but it becomes important for anything less than continuous operation. The wages of the men and the fuel consumed during start-up are added costs not necessary with induction heating. Similar are the costs during down-time, when any interruption in the flow of work requires that the furnace be held at temperature so that work can be resumed promptly.

It has been estimated that induction heating equipment requires only about ⅓ the floor space in the forge shop that a fired furnace of the same capacity would need. Auxiliary electrical equipment may be located elsewhere, as would the fuel storage for a fired furnace.

The possibility of eliminating the heat, and occasionally smoke, of a fired furnace makes for better working conditions, especially in summer. In addition to lessened employee dissatisfaction, there is greater efficiency in performing the work when temperatures in the shop do not become oppressive.

Induction heating is fast heating. With close coupling and high power input, heating rates of the following order can be expected:

Size of work	*Forging Temp.*	*Time to Reach*
1½-in. dia. bar	2100 F	9 sec.
3-in. dia. billet	2300 F	110 sec.
5-in. dia. billet	2300 F	240 sec.

This high rate of heating is associated with the reduction of scaling, and also figures in the ready adaptation of the process to automatic operation.

By careful timing of the heating of the first few pieces of work to forging temperature, and keeping the same rate of energy input and same time of application, each succeeding piece of steel of the same composition will be raised to the same temperature. Time and electrical energy can be measured accurately and easily. They can also be used to actuate controls of many different kinds. Thus, use of electrical energy for heating makes possible the accurate control of the energy input to each piece, and the automatic operation of the process. Improved quality of the work, and longer life for the dies, are two of the gains possible here.

The problem of localizing the heat is not as important in forging as in heat treating, but cases do arise in which it is necessary. It is accomplished with comparative ease by induction heating. The gain is not reducible to a monetary basis, but is very real nevertheless.

There are several disadvantages to the use of induction heating, in addition to the paramount one of higher cost. The claim that the equipment and controls were fragile is no longer valid for the present-day heaters, and especially for the motor-generator sets that comprise the greatest part of the equipment used for induction heating for forging of steel. More immediate problems are:

1—The steel must be forged in one operation, or permitted to cool to approximately room temperature, and then reheated. If the hot billet were returned to the induction heater for reheating, the coils would be damaged. This imposes limitations upon the forging of complicated pieces.

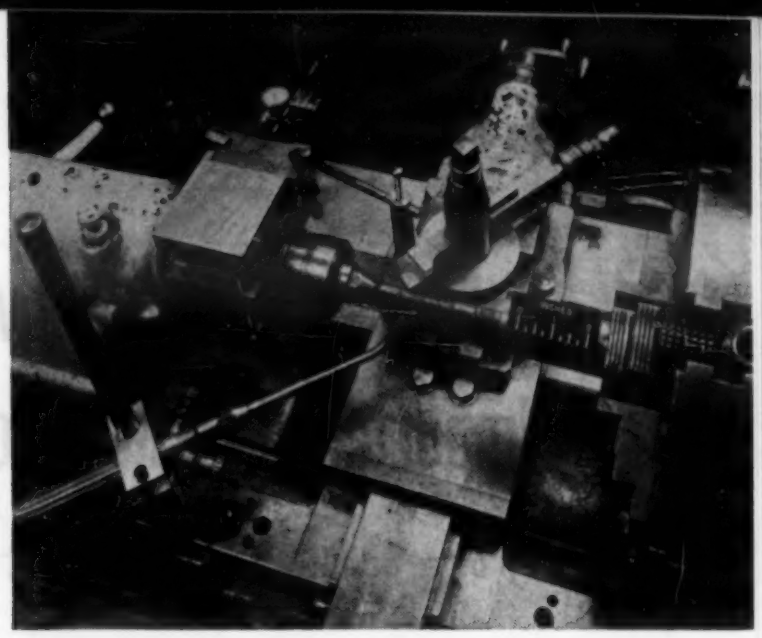
2—Design of coils for highly irregular forms becomes a difficult matter.

3—The initial cost must include auxiliary equipment, and this equipment, such as motor-generator sets, may sometimes be housed at a distance from the heater. A separate building may be advisable for the electrical equipment for a large shop.

4—The process is most efficient when used for long runs. It is not easily applicable to the job shop schedule, where short runs and a wide variety of work are the rule.

After balancing total overall costs for heating billets for forging, there is still a choice between induction heating and heating in fired furnaces. The careful engineer will study direct costs and the corollary savings to be made by each method, and decide upon the basis of these overall net costs. Induction heating frequently shows advantages when small parts are to be forged to close tolerances in one operation, or in successive operations in one heat. Heavy steel billets to be drop forged, or press forged to liberal tolerances, or requiring reheating for completion, may not offer sufficient savings of the sort indicated to offset the higher heating costs.

Application of Heat to Swaged Tungsten Permits Parts to Be Machined



The heating torch in the foreground keeps the part at proper temperature during machining.

by **DAN WHITE & J. J. AUST, JR.,**
National Advisory Committee for Aeronautics

TUNGSTEN PARTS FORMED BY SWAGING have usually been finished to final dimensions by grinding or forging. Forging, however, is often impracticable, and grinding is a slow and difficult procedure on many shapes. In many applications, especially where considerable metal must be removed, machining would be a highly desirable method. But in the past machining has not been possible because of the extreme hardness of swaged tungsten. The Cleveland Laboratory of the National Advisory Committee for Aeronautics has now developed a machining method whereby swaged tungsten is successfully machined by heating the part during the cutting operation.

When the Cleveland Laboratory began working with swaged tungsten for high temperature work, it was decided to experiment with all possible machining tools to find, if possible, a satisfactory method of machining tensile and stress-rupture specimens. First, all the available tool steels and tungsten carbide tools were tried both with and without coolants. However, none of the results were encouraging. Since tungsten carbide tools were reported to function when red hot, an investigation was then undertaken to see if tungsten could be machined at elevated temperatures.

An accompanying photograph shows the set-up for machining test specimens of swaged tungsten. A standard 12-in. toolmaker's lathe was used. The work pieces were heated by means of an oxyacetylene torch positioned on the lathe as shown in the illustration. The lathe was equipped with an air hose through the spindle to cool the head stock. Another air hose was attached to the tool bit as shown. The air passage in the tool shank was drilled to discharge downward to cool the apron and ways. It was found unnecessary to cool the tailstock or live center. An extension collet was used to reduce the heat conducted to the lathe chuck. A Carboloy No. 883 tool was used in all the work.

Machining Procedure

A swaged tungsten bar was first placed in the lathe, rotated at 29 rpm., and heated by the torch to a medium cherry red, about 1300 F. The use of a pyrometer proved impractical, so all temperatures were estimated.

First, a 0.028-in. cut was made along about one-half the length of the bar at a feed of 0.0031 in. per rev. After this cut it was found that a thin layer of green tungsten oxide formed on the work piece directly over the torch flame. The finished cut had a deep blue color.

The same machining conditions, but without the application of heat, were used on the other end of the bar. The bar after these two operations is shown in an accompanying photograph. A taper of 0.050 in. is indicated on the nonheated end of the bar showing approximately 0.025-in. tool wear due to cutting the tungsten cold. The other end that was machined hot measured only 0.001 in. smaller at the end of the cut. This small amount of taper was probably due to expansion of the tungsten because of the slight heat variation along the bar. No tool wear was observed.

The test bars were then machined to the proper contour using a template and dial gage. Speeds were increased to 187 and then 229 rpm. The feed of 0.0031 in. per rev. was maintained. Faster cutting speeds were not tried, because the operator experienced difficulty in following the contour with the dial gage under these conditions. Cuts were also made at temperatures lower than 1300 F and increased tool wear was observed. At 900 F tool wear was about one-half of that at room temperature.

After these preliminary cuts, five stress rupture bars were machined, using cuts of 0.006- to 0.010-in. depth, a speed of 90 rpm., and a 0.0031-in. feed with the work held at 1200 to 1400 F. Upon completion of these cuts, the finished bars were ¼-in. dia. for a length of 1 in. They had a thin coating of blue oxide. The finish was about 50 microin., which was considered good enough for stress rupture bars.

The carbide cutting tool used in machining the five bars had to be reground after three bars. The results, therefore, of these tests showed that swaged tungsten can be machined by machining it at around 1300 F. It may be found through future research that the machining can be economically done at higher temperatures, possibly in a protective atmosphere.

Surface Oxide Removal Important in Final Processing of Aluminum

by D. E. DURKIN, Thomson Laboratory, General Electric Co.

THE TREATMENT OF ALUMINUM prior to final processing involves both the removal of the impurities and of the oxide film from its surface. If these oxides or impurities are not removed, the quality of the finished products is seriously affected. In welding of all types, and in resistance welding in particular, electrode life is decreased and the quality of the weld is affected by the presence of these surface oxides. In chemical processing, such as anodizing or chromate finishing, either or both appearance and weathering resistance are affected.

Removal of oxides from aluminum before processing, while not novel, is nevertheless not standard practice. The advantages of it, though, are patent. If the oxides are not removed before chromate finishing, for example, the rate of the chromate film formation is not uniform. This is due to differences in the natural oxide film on the part being processed. On cast parts on which oxides have not been removed, the resultant chromate coating is nonuniform in appearance, is dusty, and has poor corrosion resistance. On parts from whose surface the oxides have been removed with a caustic type solution, the resultant chromate film is spotty; this is readily shown up in salt spray tests.

Using more effective acid-type agents, the corrosion in salt spray is more uniform and the rapid spotting noted with caustic oxide removers is not encountered. While the above is not so easily found in anodizing, nevertheless the anodic film is built up in a much shorter period, since the base metal is more uniform.

In the case of welding, a good deoxidizer will decrease the frequency of electrode dressing. Tests on aluminum, other than on 2S, and not using an oxide remover, have shown that as few as six welds were obtained before electrode cleaning was necessary. With acid removal of oxides, however, while no actual electrode life tests have been made, as many as 50 welds have been obtained without electrode dressing.

If aluminum is to be resistance welded, finished or otherwise processed after casting or forming, it is important that surfaces be both cleaned and have oxides removed.

Two Steps Necessary

In preparing aluminum for processing, two operations, cleaning and oxide removal, must be considered. The two operations are frequently confused and used synonomously, but they are quite different. In cleaning, dirt and grease are removed with inhibited cleaners, which will not attack aluminum under any condition, while in oxide removal the oxide film is removed by mechanical means, such as wire brushing, or chemically, by treating in either solution or reducing-type reagents. Regardless of the oxide removal method used, however, cleaning and deoxidizing cannot be separated when uniformity and quality products are desired. If parts are not clean, they cannot have their surface oxides removed uniformly.

In cleaning aluminum, particularly where buffing compounds are present, two operations are considered necessary: (1) solvent-type degreasing, and (2) inhibited alkali cleaning. The degreasing is used to assist the inhibited alkali cleaner, which is generally less potent than an uninhibited alkali cleaner because of the presence of the inhibitor. Its use extends the life of the inhibited cleaner and allows for closer control of it. This control is important to insure adequate cleaning action and to prevent staining of the work.

Solvent emulsion-type materials are generally used in process-tank lineups. It is important that these materials have no effect, even after extended immersion periods, on the aluminum.

An effect can be determined by immersing a polished panel of 2S aluminum in a solution of the cleaner under consideration or by determining the pH value of it. The latter is a fast way of evaluation, and eliminates the preparation of panels for the former methods. Aluminum etches at a pH of 10 and any material testing above this value should be avoided. An accompanying table gives pH meter values of seven common emulsifying concentrates. Investigations of all were made at the Thomson Laboratory of the General Electric Co.

It is evident that those materials with high pH values should be avoided, particularly in production lineups where the work remains immersed in the cleaner for periods even as short as 3 to 5 min.

Inhibited aluminum cleaners, which are used with emulsion cleaners, should have no effect on aluminum.

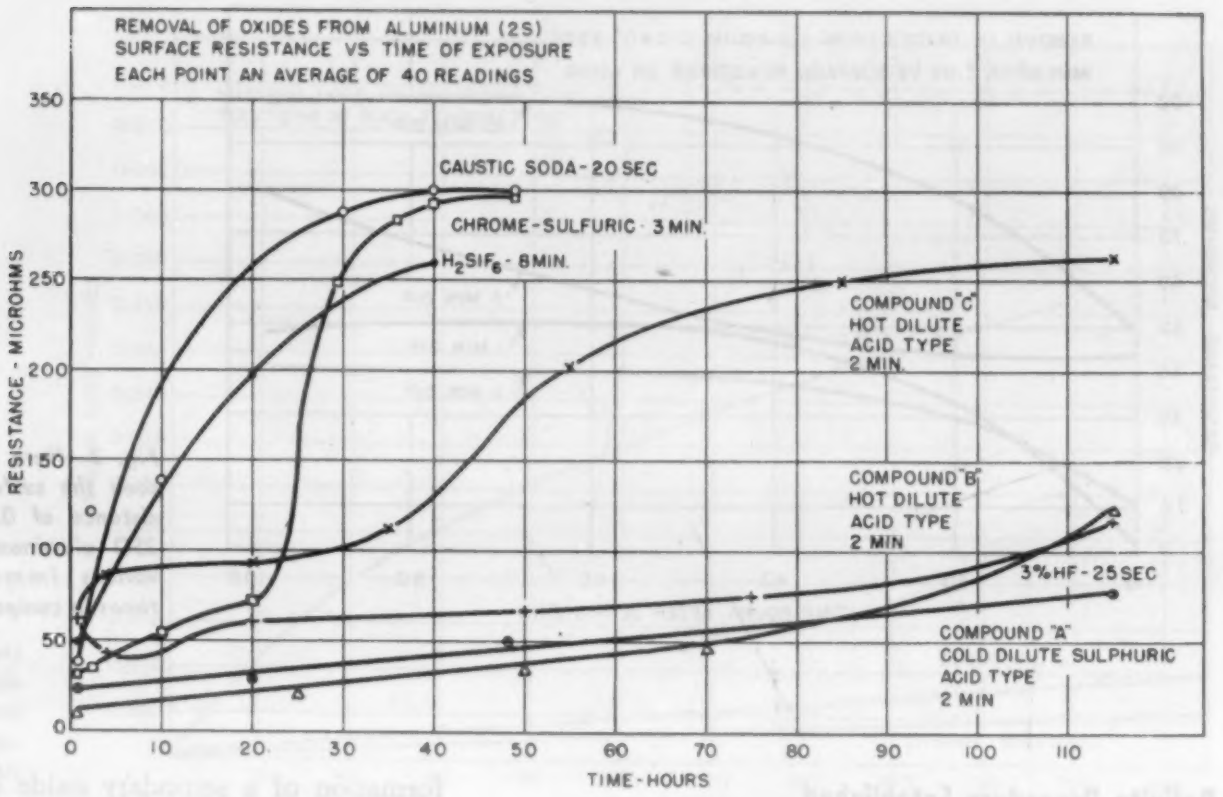


Fig. 1—From data on this chart can be determined optimum treating time at a definite concentration of an acid-type deoxidizer.

These are alkali cleaners, inhibited with silicates or chromates. The inhibitors, in many cases, are difficult to get into solution, and must be boiled thoroughly before lowering the temperature to the operating level of between 160 and 180 F.

These cleaners are generally weak because of the inhibitors and, therefore, are best used in conjunction with emulsion cleaners mentioned above. The most inhibiting action of the cleaner, the weaker it is. This is due to the passivation that takes place on the aluminum, preventing further action of the cleaner on it. The polished panel test, likewise, can be used in selecting a suitable cleaner along with such tests as ability to clean, ease of rinsing, etc.

Partially inhibited cleaners which show little effect on cast stock because of casting skin and other factors may readily attack the polished sample during short-period immersions. Rinsability characteristics should not be considered lightly, inasmuch as surface resistance values, considered later, are definitely affected. Poor rinsability characteristics may also necessitate the use of additional acid tanks in the production lineup.

After parts have been thoroughly cleaned, they are ready to have the surface oxides removed. The two types of removers generally used are acid and alkalis. Alkali oxide removers were not evaluated extensively during the investigation. It was felt that, in general, their action is too fast and that they require close control. Acid-type deoxidizers generally used were tested and the results evaluated.

No consideration is given to mechanical methods of oxide removal because of the high labor costs involved and the difficulty in obtaining uniform results on critical work.

Surface resistance values for welding tests were determined by passing a current of 10 amp. through the line. With the leads to a voltmeter on either side of the junction of the two metals held under a 1,000-lb. pressure, the voltage is read on a voltmeter which is calibrated as an ohmmeter.

The following data are presented only to show what can be expected in uniformity in treating aluminum, and that different oxide removers have vastly different characteristics. In no way is it presented as absolute data but only to show those factors that should be considered in selecting a suitable agent for removing aluminum surface oxides.

Table 1

	Caustic Soda	Chromium Sulfuric Acid	Hydro-fluoric Acid	Hydro-fluo-silicic Acid	Compound A (Curve 1)	Compound B (Curve 1)	Compound C (Curve 1)
Concentrate	12.03	11.80	8.10	10.30	11.02	10.26	10.23
Diluted 9:1 with Petroleum Spirits	12.39	11.90	8.45	10.91	11.69	10.45	10.13

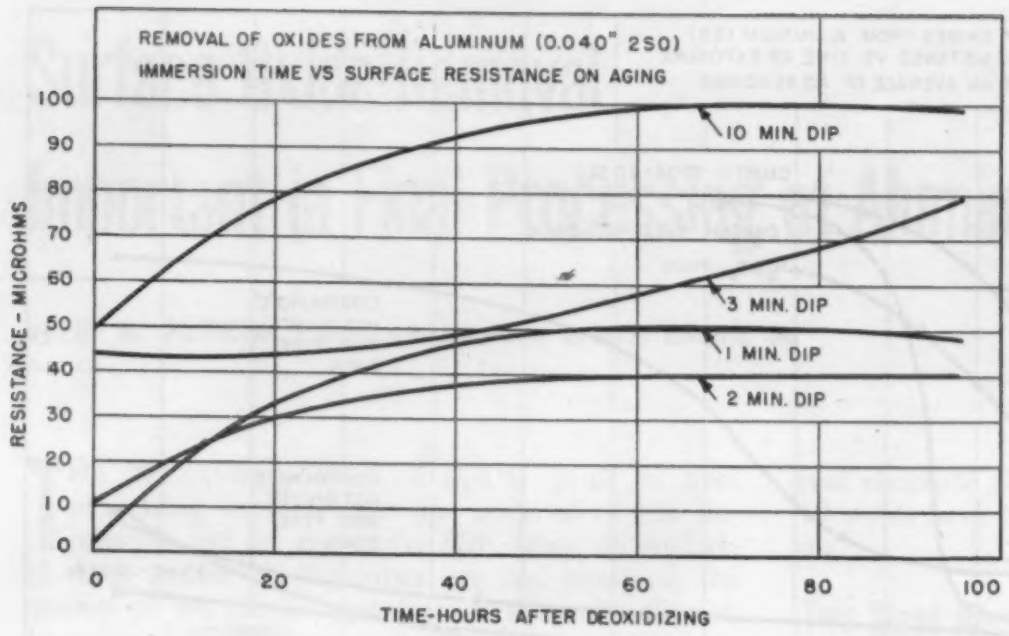


Fig. 2—Here can be seen the surface resistance of 0.040-in. 2SO aluminum after various immersion times in compound A.

Definite Procedure Established

A definite procedure was established before testing the materials. It included emulsion dip, hot rinse, spray rinse, inhibited cleaner, rinse, spray rinse, removal of oxides from surface, rinse, dry, and test for surface resistance, in that order.

The oxide removers evaluated included chromium sulfuric, chromium phosphoric, hydrofluoric and hydrofluosilic acids; caustic soda; and three dilute acid-type compounds. Panels treated with the materials under test were 2SH, 2SO, 3S, 14ST, 4 by 5 by 0.050 in. or 0.040 in. The optimum processing time for each material was determined for each test. These tests also showed that type of material, thickness, processing times and temperatures were critical.

The importance of treating time can be seen from the following data: Samples of aluminum were processed at the same temperature at various times in caustic soda. The results on surface resistance values are noted in Table 2. These values were recorded at 500 psi. and 1,000 psi. The latter pressure proved the more satisfactory, inasmuch as readings are more consistent and lower. Each value shown is an average of 40 readings.

These results also show that while high surface-resistance values are obtained before removal of surface oxides, because of the natural oxides on the aluminum, they are likewise obtained because of the formation of a secondary oxide caused by overtreatment. This is true in the case of all the oxide removers tested. While a 20-sec. immersion shows the lowest surface resistance values, there is a factor (reoxidization) to consider and which may be the most influencing factor for the operation in question. Reference will be made to this characteristic in Fig. 2. Fig. 1 shows the optimum treating time at a definite concentration of an acid-type deoxidizer.

The effect of temperature on the surface resistance is also noticeable. Spot checking caustic soda in a 30-sec. immersion produced the results in Table 3.

Surface condition and material likewise affect surface resistance. Shown in Table 4 are values obtained using 0.040- and 0.051-in. 2SO; 0.030-in. 24ST; and 0.048-in. 2SH.

In many operations, it is difficult to process the parts immediately after deoxidizing. It is, therefore, important that the material used to remove surface oxides should also retard their redevelopment. Fig. 2 shows the surface resistance of several materials used in many production set-ups. Initial low readings, are, of course, advantageous. The immersion time indicated in each case was obtained in the same manner as Compound A in Fig. 1.

Conclusions

The following observations on the materials tested were as a result of tests made at the Thomson laboratory; it was possible to draw several conclusions.

Table 2—0.040-In. 2SO Aluminum

Time of Etch (Sec.)	Temperature	Surface Resistance	
		500 Lb.	1000 Lb.
0	—	—	2591
10	180 F	1118	134
20	180 F	246	86
30	180 F	3470	170
1 min.	180 F	1832	203
2 min.	180 F	4363	437

Table 3—0.040-In. 2SO Aluminum

Temperature	30-Sec. Immersion Surface Resistance 1000 Lb.
150 F	334
165 F	473
180 F	170

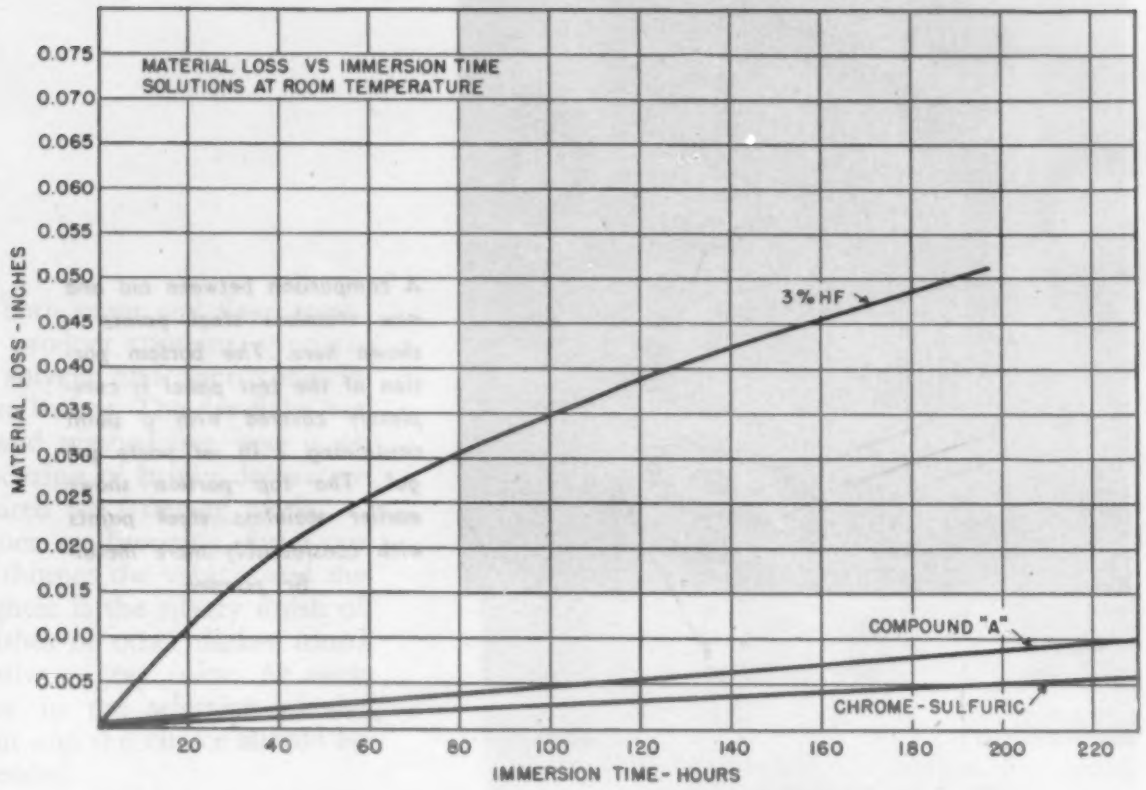


Fig. 3—Material loss varies with the oxide removing agent and the time of immersion, as shown by this set of curves.

(1) Caustic soda is not a satisfactory oxide remover because the surface resistance is not uniform or sufficiently low to insure good processing. Other undesirable characteristics are its critical immersion time, and, in most cases, unnecessary etching action on the material. Close concentration and temperature controls are also required.

(2) Chromium-sulfuric acid has low surface resistance values, the immersion time is critical, and the allowable time of exposure before reoxidization short.

A chromium-phosphoric acid solution, which is a common surface oxide remover, is not shown on the curves, as preliminary tests indicated that this agent did not give the surface uniformity immediately after treatment, as did chromium-sulfuric acid.

(3) Hydrofluoric acid gives low initial resistance values, but the immersion time proved prohibitively critical. An oven treatment of about 10 sec. resulted in etching and high surface resistance.

(4) Hydrofluosilicic acid did not produce sufficiently low surface resistance. This was also tested with a wetting agent. Resistance values, however, were not sufficiently low and reoxidization of the surface was rapid.

(5) Compound A had low surface resistance values and retarded oxidation. This is considered a satisfactory deoxidizer.

(6) Compound B had low surface resistance values. The time of immersion, however, was critical.

(7) Compound C does not yield low resistance values nor retard reoxidization. The exposure time was also limited.

Table 4—30 Sec., 180 F

Material	Surface Resistance 1000 Lb.
0.051 in. 2SO	383.0
0.040 in. 2SO	170.0
0.030 in. 24ST	22.6
0.048 in. 2SH	26.3

The importance of good rinsing facilities in these operations cannot be over emphasized. Surface resistance values using Compound A on 2SO, 0.040-in. aluminum with proper rinsing showed an average of 12 microhms surface resistance; with indifferent and inadequate rinsing on tests run at the same time, surface resistance values of 2500 microhms were obtained.

Fig. 3 indicates the material loss of the two deoxidizers with the lowest surface resistance values shown in Fig. 2. While no such long immersion times would be obtained in practice, these curves show the relative safety of the three materials tested on aluminum. Hydrofluoric acid is included for comparative purposes.

In setting up a process that includes the use of surface oxide removal agents, it is important to select the one which is most suitable for the material under consideration. Consideration must be given to the number of tanks involved in using the agent, the controls necessary to maintain the concentrations and temperatures, and the special equipment which may be necessary for the particular agent selected, which in some installations may make the cost prohibitive.

When parts have been properly cleaned and deoxidized, the maximum weathering resistance, adhesion and uniformity of the final inorganic coatings are insured. In welding, uniformity and quality of welds will be likewise guaranteed.

A comparison between old and new stainless steel paints is shown here. The bottom portion of the test panel is completely covered with a paint containing 2 lb. of paste per gal. The top portion shows earlier stainless steel paints with considerably more metallic powder.

Stainless Steel Paint Offers Corrosion Resistance, Hardness and Attractive Surface

by GEORGE BLACK

INDUSTRY IS WELL AWARE of the numerous advantages offered by commercially available chromium-nickel stainless steels, and any development which hints at the possibility of securing these same advantages at an appreciably lower cost merits the full attention of a wide audience. The recent announcement by Charles Hardy, Inc. of their success in preparing stainless steel in flake and paste form, so that it can be mixed conveniently with a variety of vehicles and applied in the same manner as other paint coatings containing metallic pigments, has been attracting just such attention from interested design engineers and manufacturers.

With the advent of stainless steel in flake and paste form, stainless steel paint is now possible for use under corrosive conditions and as a finish for products which must withstand constant exposure.

Utilizing 18:8 chromium-nickel stainless steel powder, the new finish dries to an exceptional hardness, possesses unusual corrosion resistance, excellent hiding characteristics and covering, and can be used for the acquiring of special decorative effects. The very origin of its development is indicative of the possibilities it offers for increased corrosion protection, for it was actively developed in an attempt to overcome the repeated paint failures on the exhaust fans used for ducting acid fumes. In one stance, the blades of an exhaust fan used for ducting nitric acid fumes required repainting every two weeks. When the blades were painted with an experimental stainless steel paint mixture, the service life was extended to six months and longer.

Other research studies indicated increases as much as 300% in the working life of a painted surface. These experiments were sufficient to show the value of continued study, with the result that 18:8 stainless steel paint is now being marketed in increasing quan-

tities, and is available in both paste and flake form.

In the paste form, the product contains approximately 14% Varsol as a solvent and approximately 1% stearic acid to facilitate leafing. The dry flake has had most of the stearic acid washed out, and is of particular value for the securing of bright decorative effects such as those required for lettering work.

Almost any clear lacquer or bronzing fluid can be used as a vehicle. The thinner the vehicle and the more transparent, the brighter is the silvery finish of the dried film. Spar varnishes or other darker toned vehicles will produce a silvery gray color. As with other metallic paints, care in the selection of the proper vehicle is important and the choice should be related to the service intended.

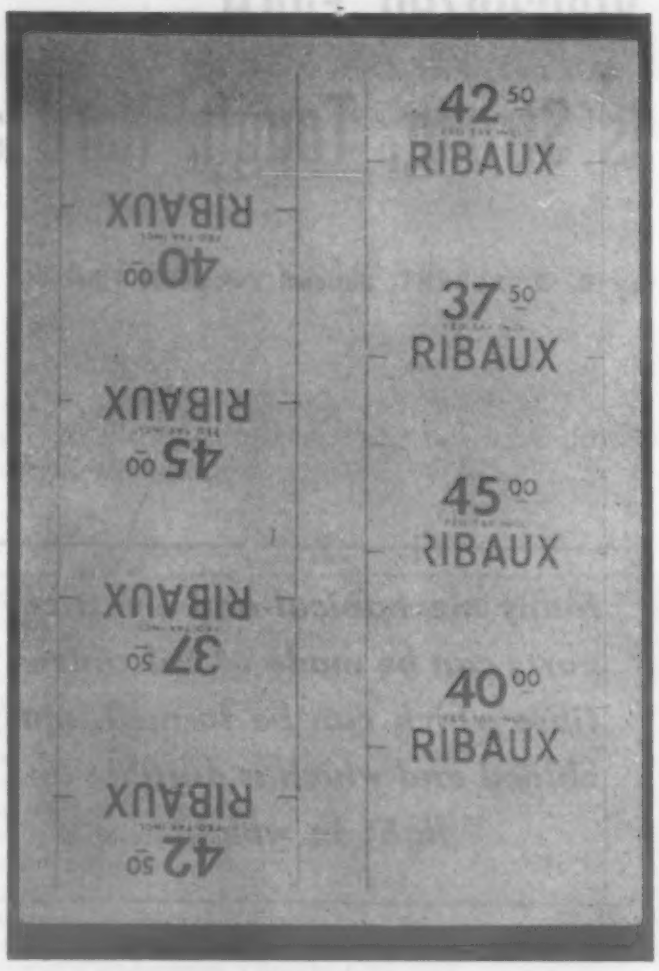
Precautions should be taken during the mixing of the paste and vehicle to assure that the tiny stainless flakes are brought into solution; and occasional stirring is recommended to prevent their settling out. For normal requirements, 2 lb. of paste per gal. of solution will be found adequate. An accompanying illustration shows the improvement made in the present product as compared with the experimental material originally produced with respect to texture, hiding and coverage. (Note the rough porous quality of the original material, even at 4 lb. per gal.)

The dry film is an attractive silver gray with the unique bluish cast of stainless steel. Although originally recommended only for corrosive conditions where other commercially available paints were found inadequate, product designers are coming forward with new uses. It is being suggested as a maintenance finish for bridges, exhaust ducts and fans, boat bottoms, heavy machinery, battery boxes and similar applications which require protection from severe weathering and corrosive media. Since the flake will stay bright and will not deoxidize plastics, it is especially suited for decorative work where plastics are concerned.

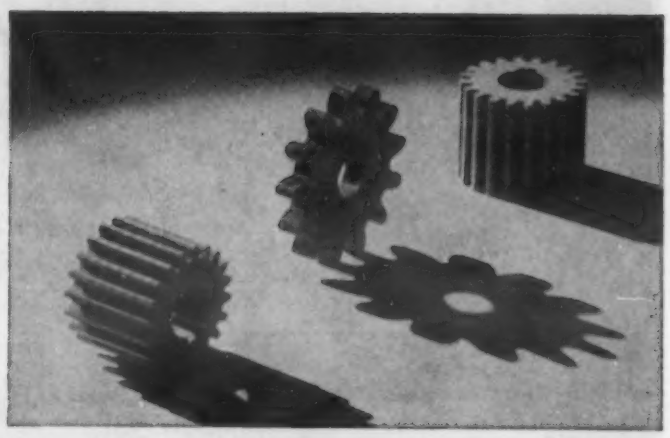
Stainless steel paint has also been recommended for coating paper and paper products, and for the spray coating of wire, metal frames and other parts requiring a hard, resistant surface. Because it will not tarnish with age, stainless steel flake is especially useful for lettering work and outdoor signs where a permanent bright surface is required. Recent tests indicate that maximum acid resistance is achieved using a vehicle containing chlorinated rubber and vinyl resins.

At the present time, extensive tests are being conducted by various groups to determine the durability of this new paint under various corrosive and wear conditions. From the information currently available, it seems certain that stainless steel paints will play an important role as a protective and decorative finish of extremely high quality.

The outside surfaces of this bank night depository have been covered with the new-type stainless steel paint. (Courtesy: Stuart-Dean Co., Inc.)



Stainless steel flake is used in this example as backing for clear plastic. (Courtesy: Charles Hardy, Inc.)



Hard, "bone" fibre is easy to machine, and, being resistant to wear and abrasion, is well suited to making noiseless gears such as these.

Vulcanized Fibre

Is Strong, Tough, Hard and Easy to Work

by G. A. ALBERT, National Vulcanized Fibre Co.

Many mechanical and electrical parts can be made of vulcanized fibre which can be formed, machined and which is durable and light in weight.

ONE OF THE OLDEST MEMBERS of the plastics family, vulcanized fibre, has steadily been expanding its field of usefulness since it was patented in 1859. It is now an indispensable material in thousands of industrial applications both mechanical and electrical.

Vulcanized fibre is a converted cotton cellulose material, hardened by a chemical which is later removed, leaving a pure, hard, tough, mechanically strong and electrical insulating material. Fundamentally, it is made by passing a special chemically reactive cotton paper through a zinc chloride bath, which attacks and gels the surfaces of the individual fibres of the paper, causing them to adhere to each other in the same sheet, as well as to those of adjacent sheets. After passing through the treating bath, the plies are pressed together between large cylinders to aid lamination, and then run through a series of water tanks to leach out the zinc chloride, leaving the pure converted

An idea of the wide range of parts being made of vulcanized fibre can be obtained from those shown here. As is evident, the material can be stamped, drawn and machined.

cellulose which is dried and calendered or pressed.

Vulcanized fibre is a hard yet tough and strong organic plastic material. It possesses high mechanical strength, particularly impact (shock absorbing), good electrical insulating properties, excellent machinability, good forming and drawing qualities, high resistance to wear and abrasion, durability and light weight (one-half the weight of aluminum).

There are but four Nema classified grades of vulcanized fibre, namely Electrical Insulation Fibre, Commercial (electrical and mechanical), Bone (high density) and Trunk. Many variations of these have been developed for special purposes, and today about 30 distinct grades are available. The chief commercial colors are gray, red and black. Colors for special applications are russet, mahogany, olive, walnut, white walnut, brown, green, canary, blue, purple, orange, etc. Vulcanized fibre is made in sheet and tubular form only, rods are machined from sheet material.

In Table "1" are listed the ranges of some properties of vulcanized fibre:

Table 1

Tensile Strength (psi.)	6,000-12,000
Flexural Strength (psi.)	12,000-20,000
Compressive Strength (psi.)	20,000-30,000
Shear Strength (psi.)	11,000-15,000
Impact Strength (ft.-lb./in. notch)	4-8
Rockwell Hardness	R-60-R-100
Modulus of Elasticity (psi.)	750,000
Density (gm./cc.)	1.0-1.5
Density (lb./cu. in.)	0.036-0.054
Dielectric Strength (short time ⅛-in. volt/mil)	150-250
Power Factor, 1,000 kc.	0.03-0.08
Dielectric Constant 1,000 kc.	4-7
Water Absorption (2 hr.—⅛-in. thk.)	15-25%
Thermal Conductivity (Btu/hr./sq. ft./F/in.)	3
Specific Heat (Btu/lb./F)	0.37

One of the earliest—and still important—uses of vulconized fibre was in trunk making.

Machining and Fabricating

Probably the chief reason why vulcanized fibre has become a staple material in all industries is its exceptional machining characteristics. It can be sawed, sheared, drilled, tapped, milled, turned, threaded, punched, planed, shaped, spun, and shaved with ease.

Machining of fibre follows in general the methods used for metals, and standard machining equipment used in both the metal and woodworking industries is adaptable for fabricating vulcanized fibre.

For shearing, metal squaring shears operating up to 50 strokes a min. are adaptable. Fibre ¼-in. thick can be sheared with good edges. Rotary shears will shear or "slit" fibre up to 5/32-in. thick.

Band-sawing can be satisfactorily done with standard woodworking band-saw equipment using high carbon steel tempered saws. Smooth sawing is done with hollow-ground circular saws mounted in a woodworking saw table. High carbon steel tempered saws should be used. Surface speed should be close to 13,000 ft. per min.

Punching is done with standard power-driven vertical or inclinable presses on fibre up to ¼-in. thick.

For drilling, standard drills are satisfactory, and single, gang or multiple drill presses are used. The surface speed of the drill can go as high as 400 ft. per min.

Threading can be done on hand or automatic screw machines, lathes and turret lathes. High-speed steel dies give satisfactory results.

Turning, facing, boring, etc. should be done with high-speed steel or carbide-tipped tools having a negative rake similar to the practice followed in machining brass.

Forming

For forming, standard press equipment is satisfactory. The pressures required depend upon such factors as the shape of the part, depth of the draw, and thickness of the fibre. Deep-drawn parts such as helmets and welders' shields require pressures on the projected area of about 200 psi. For larger items or for parts where only the periphery is to be formed, such as cylindrical covers or bases, the force needed is usually calculated on the linear dimension of the periphery. This value rarely exceeds 700 lb. per lineal in.

Many formed parts can be made in regular 2-piece dies, but where the draw is severe pressure pads are necessary. The purpose of the pressure pad is to prevent the fibre from wrinkling and to hold the fibre taut so that it can be stretched to the desired shape. Fibre of all thicknesses can be formed, but most of the commercial objects are made from fibre 1/32- to 3/16-in. thick. This thickness allows good drawing, yet imparts ample strength and rigidity to the finished part.

While vulcanized fibre shows no tendency to soften when heated at temperatures below 250 F, it displays a softening when heated in the range of 325 to 450 F. When heated to this temperature it can be bent and formed with heat alone to approximately the same degree as is obtained with postforming laminated phenolic materials. However, the amount of draw or bend that is possible with heat alone is considerably less than that which can be obtained when the fibre is wet.

Fibre can also be swaged by forcing it into die cavities under high pressure. This usually is done dry with the application of some heat. The tremendous pressure forces the fibre to flow, filling the die cavities. The action is similar to that of thermoplastic compounds under pressure in an injection molding machine.

The uses of formed vulcanized fibre are varied and many. The chief uses are the protective parts of athletic equipment (chiefly football), miners' helmets, arc welders' protective shields, covers, etc. Some of these parts are illustrated.

Applications

Fibre Overlay on Plywood

From the very beginning, trunk manufacturers wanted to use plywood for making trunks and containers but first had to find a suitable tough covering to prevent splintering and chipping, and especially to protect the plywood from damage from sharp objects. Many materials were tried but without success until vulcanized fibre of thicknesses from 0.010 to 0.025 in. was glued to the wood. This construction was the answer, for fibre satisfactorily glued to the surfaces as well as to the edges of the wood stays on even though immersed in water for weeks, prevents splintering and chipping and protects the trunk during transit, but above all, increases the shock resistance of the trunk. By actual dropball tests vulcanized fibre surfaced plywood is about nine times stronger in impact than the unprotected plywood.

In recent years a method was developed whereby white fibre can be lithographed by standard procedure with bright colors. This was an innovation to manufacturers making plywood objects such as serving trays and casseroles. Now these manufacturers have a durable, brilliantly colored surfacing material which has materially increased their sales.

Sterilized Fibre

Fibre is hygienically clean. It is used as gaskets in milk pasteurizing equipment, for reels for holding sterilized surgical sutures, and for making toys.

Self-Locking Nuts

The red plastic collar in self-locking nuts is vulcanized fibre. These nuts have a recess in them to accommodate the fibre collar washers in such a way that as the bolt is threaded into the metal threads of the nut, it cuts its own thread in the fibre washer. Fibre is tough and resilient and as the bolt impresses its thread in the fibre and squeezes, the fibre in turn squeezes back and holds the bolt. When the bolt is removed the resilient nature of the fibre allows it to release its stresses to become an undersize thread, meaning that when the nut is put back it will again grip and hold tight; thus it is usable over and over again.

Abrasive Disks

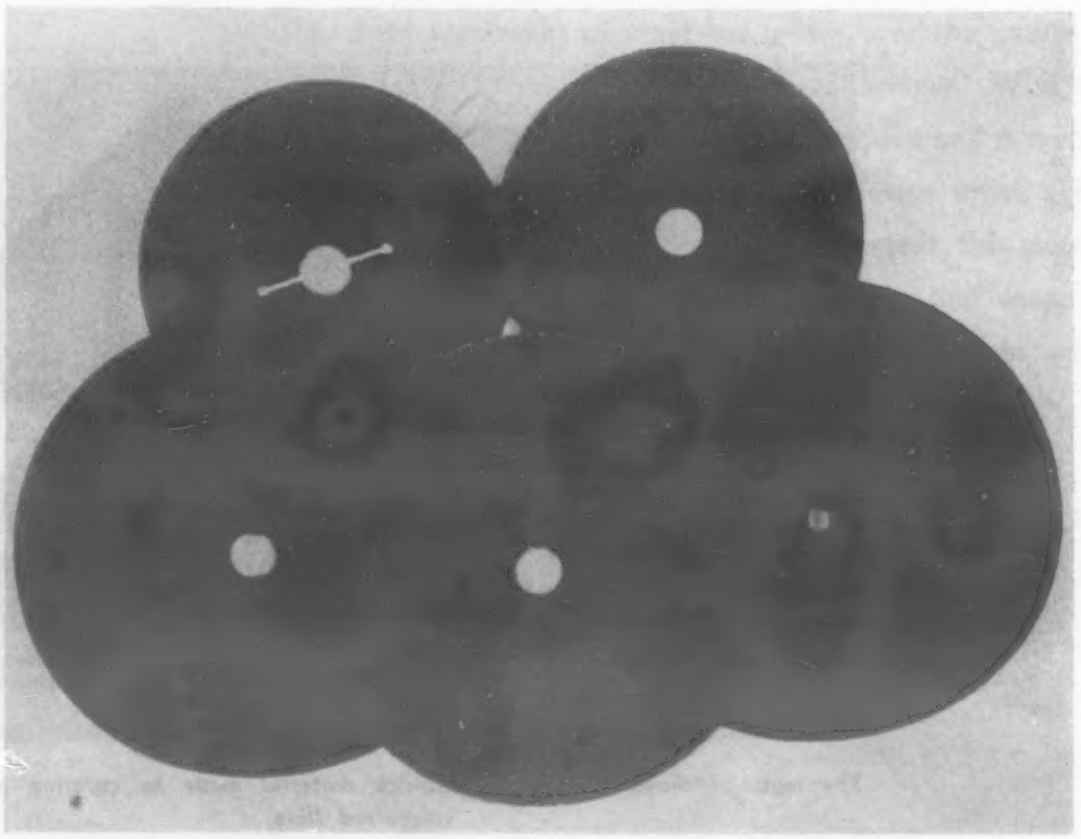
Because of vulcanized fibre's unique mechanical properties, toughness, high tensile strength and pliability, it is used in the manufacture of abrasive disks. The water soluble phenolic resinous binder is coated directly to the fibre (usually 0.030 in. thick), then the abrasive grit is snowed onto the resin. The binder is cured in ovens at about 200 F to set the resin. Some disks are made by first gluing cloth to the fibre then anchoring the abrasive particles to the cloth. Fibre abrasive disks operate at high speeds and yet are strong, tough and pliable enough to get into the sharp corners that are to be sanded.

Arc Resistance

Another very useful property of vulcanized fibre is its arc resistance. Unlike other plastic insulating materials, vulcanized fibre, when exposed to an electric arc, produces a gas and will not leave an electrically conducting carbon deposit. It is much superior in this respect to melamine or urea laminates. This is so because the cellulose molecule contains a sufficient amount of oxygen to completely unite with the carbon monoxide gas.

The gas that is formed by the arc is electrically neutral and is used to a great advantage in extinguishing arcs in such applications as electrical fuse tubes, both indoor and outdoor type, lightning arresters, disconnect switches, switch barriers, etc. The electric arc volatilizes some of the fibre to make a neutral turbulent gas which, in the case of tubes, physically blows the arc out of the tube and thereby clearing the circuit. From actual tests it was found that an arc of 2500 amp. decomposed about one-half grain of fibre per cycle.

Another big use of vulcanized fibre tubing is in the construction of lightning arresters. These devices, which are superior to the older types, are used by the hundreds of thousands. In these devices tremendous gas pressures are set up when surge currents up to 100,000 amp. are by-passed to ground, and since fibre is tough and strong, the walls of the tubes and the threads holding the end electrodes satisfactorily resist these forces.



Much of the vulcanized fibre output is used in the manufacture of abrasive disks. A resinous binder is coated on the fibre and the abrasive grit embedded thereon.

Again because of its arc resistance, vulcanized fibre punchings and sawed pieces are placed in molds and molding powders put in with them. When molded the fibre becomes an integral member of the molded part which can then be used near a live arc.

Motor Insulation

Large quantities of vulcanized fibre, commercially known as fishpaper, are used for insulating the rotor, stator, and field coils of electric motors. This thin vulcanized fibre is tough and strong and can be bent and formed, usually by hand, to fit into the slots. Millions of feet of formed fibre slot wedges of innumerable shapes and sizes are used to anchor the coils in the slots of the motors.

Case Fibre

Again because vulcanized fibre is tough, formable, and available in huge quantities, yet inexpensive, it is used in the manufacture of luggage and cases. This application is a natural, especially now for air travel where low weight and toughness are most important.

Railroad Track Insulation

Vulcanized fibre is the only material that can satisfactorily be used to insulate railroad rails from each other, because it is tough and strong enough to withstand the terrific pounding caused by every passing train. Naturally since the rails are metal and are joined together with metal fish plates from one end of the country to the other, each signal switch section has to be satisfactorily isolated. This is indeed an important assignment and vulcanized fibre has been satisfactorily used almost from the inception of electric railway signal systems.

The fibre is formed to the shape of the rail so as to fit under the fish plate. Tubular bushings are provided for insulating the bolts while punched fibre end posts of the same cross section as the rail complete the insulation.

Textile Machinery

Large quantities of fibre are used in the textile field because of its exceptional wearing properties, smooth surface, and mechanical toughness.

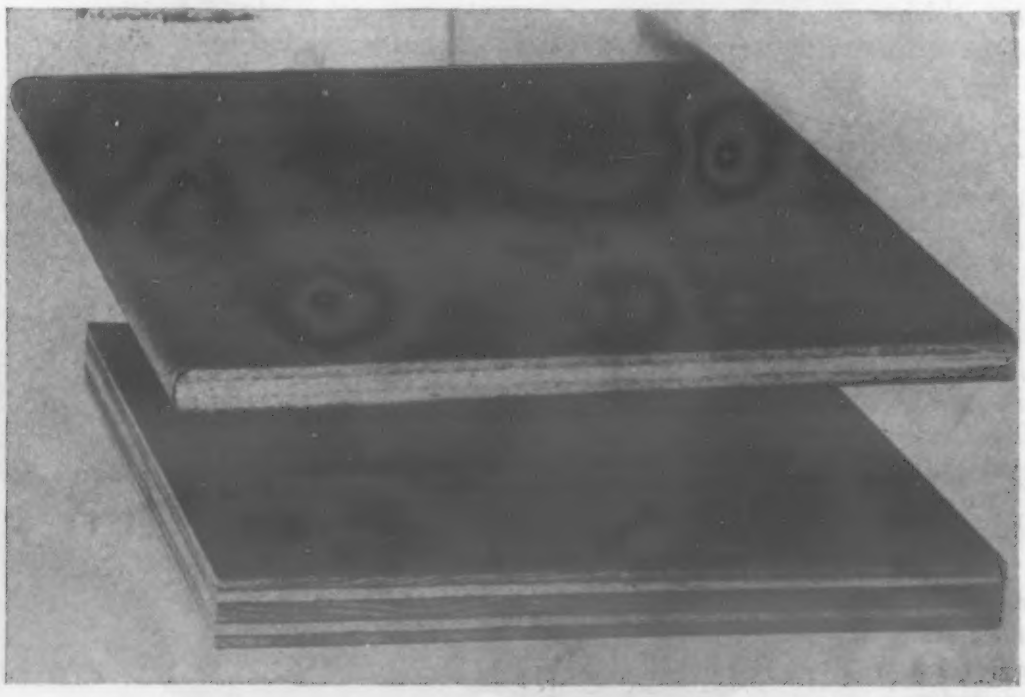
One big application is for the making of *heads of bobbins.* The fibre, when turned, takes on a glass-smooth finish; it will not break when dropped, nor become rough when bumped or struck. Further, it resists the nail, screw or rivet heads from pulling through even though the bobbin is dropped from great heights.

Another big use for fibre in the textile field is for the *surfacing of wooden shuttles.* Here fibre is glued to the wood using chiefly casein and animal glues. With the wood completely covered there is no danger of splinters because fibre itself wears with a smooth surface that is necessary in weaving the more delicate yarns such as silk and rayon, and, in addition, fibre is tough enough to withstand the severe shocks and strains normally encountered.

Heel Lifts

Vulcanized fibre softened with a plasticizer like glycerine is replacing leather as lifts on women's heels. It outwears leather lifts 5 to 1. Fibre is available in colors and the edges of the lifts don't have to be painted with dyes, as must be done with leather. The fabrication of the fibre lift, attaching it to the wooden heel and finishing it to shape, is considerably quicker than with leather lifts.

Because of the versatility of vulcanized fibre it has become indispensable to several industries, and is now being investigated for a wide group of applications.



The material shown here is a sandwich material made by covering plywood with vulcanized fibre.

MATERIALS & METHODS MANUAL

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This is another in a series of Manuals on engineering materials and processing methods, published at periodic intervals as special sections in Materials & Methods. Each of them is intended to be a compressed handbook on its particular subject and to be packed with useful reference data on the characteristics of certain materials or metal forms or with essential principles, best procedures and operating data for performing specific metalworking processes.

Steel Heat Treating Processes and Equipment

by S. D. Smoke, Associate Editor, MATERIALS & METHODS

The heat treatment of steel has grown over the course of many years from an uncertain art to a science. With the change has come many variations in practice and a myriad of equipment. Keeping in mind the confusion which exists in the newcomer to the fields of heat treatment, this manual has been written to help define the range and scope of the basic processes and principal types of equipment.

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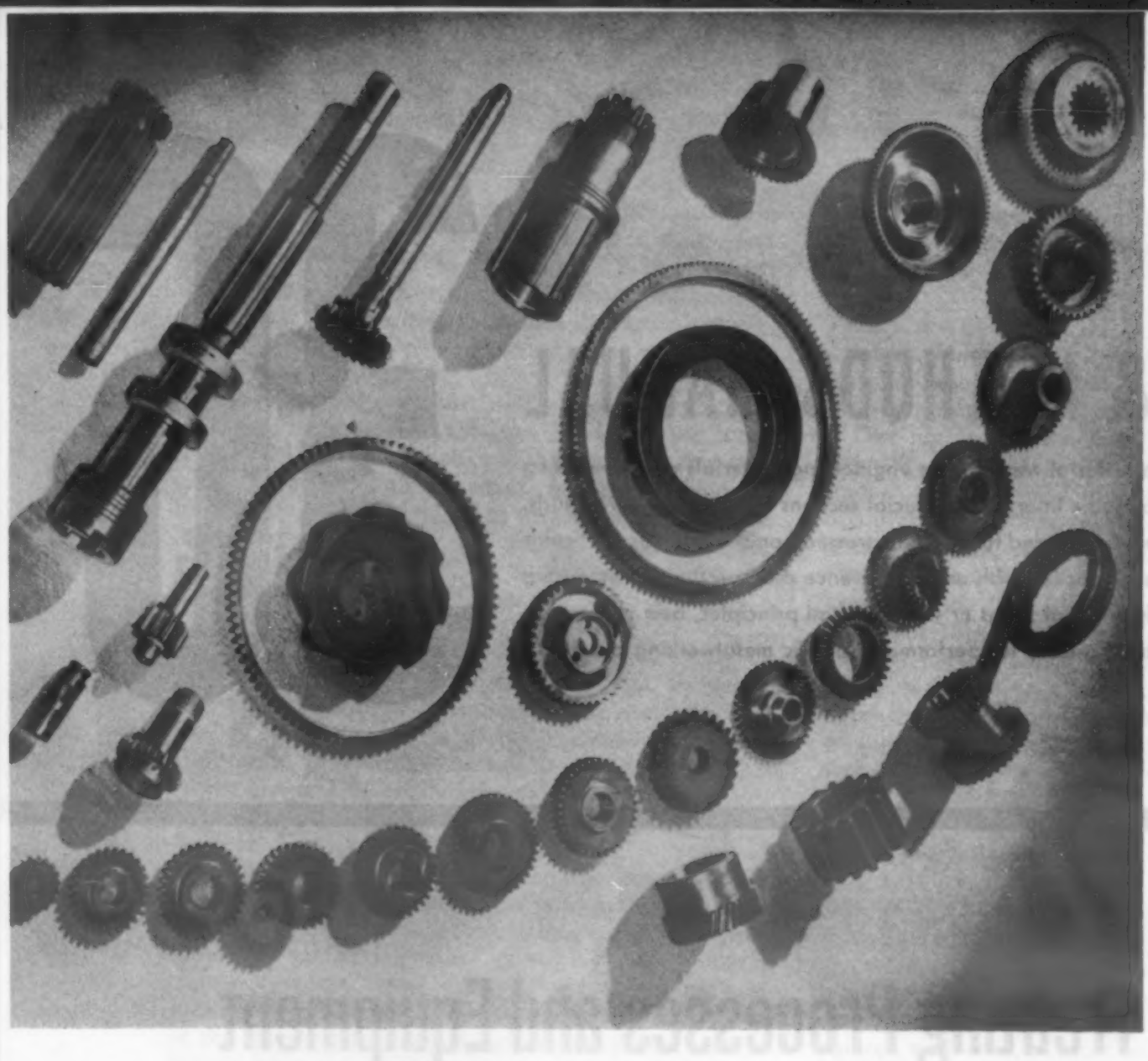


Most of the parts shown here could be heat treated by any existing methods. The method finally selected for any one part would depend on required treatment and local conditions.

Introduction

The problem of selecting and applying heat treating equipment today is complex due to the wide variety of heat treatments now in vogue. Electric and fuel fired furnaces have been made continuous in operation through the use of conveyor, roller hearth and moving car systems. Gas has been given new life in its competition with electricity through the development of radiant tube and high gradient heating. Gas has also found application in selective hardening through the development of various flame hardening machines and in control of surface carbon content by use of special atmospheres.

Electrically heated equipment such as the pit, bell, rotary hearth, roller hearth, conveyor, pusher and elevator type furnaces have been tremendously improved. Induction heating, another phase of electrical heating, has succeeded in treating individual pieces at production speeds. It has also found wide application in selective hardening and case hardening.

Molten baths have become particularly adapted to the treatment of relatively small high-speed and machine tool parts. Accessory equipment has made production treatment from these baths possible.

Development of TTT (Time-Temperature-Transformation) curves for most grades of steel has been chiefly responsible for the understanding and application of isothermal cycles such as cyclic annealing, austempering and martempering. These same curves are proving beneficial in many other respects in setting up more efficient treatment procedures.

Despite all these advancements and achievements, the practical man will still ask the age old question, how can I fulfill my production requirements most economically?

To solve this problem, it is necessary to make a selection of the proper heat treating equipment and methods or processes. This can only be done by fully understanding (1) the function of the various heat treatments, and (2) the capabilities of the equipment available to perform these treatments.

The purpose of this manual is to summarize the various methods for heat treating steel and to point out the equipment that has proved economical for particular applications. This information should be a valuable guide for selecting heat treating equipment and methods for various shop requirements.

Basically, there are three major factors to be considered in the selection of equipment. These are: (1) What treatment must the equipment perform? (2) What production schedule must be met? and (3) What equipment is most economical?

What Treatment Must the Equipment Perform?

Annealing consists of controlled slow cooling from above the critical range to increase machinability, to permit additional cold working, to relieve stresses or to obtain a definite structure.

Bright Annealing utilizes a protective atmosphere in its annealing cycle to produce a clean, bright surface.

Spheroidize Annealing, prolonged heating at the lower critical temperature, results in the formation of spheroidal carbides instead of the normal lamellar carbide structure.

Isothermal (Cycle) Annealing is a short controlled cooling cycle to produce a stress-free product of the desired hardness and structure.

Normalizing is similar to annealing except that cooling is done more rapidly, in air.

Carburizing is the surface impregnation of steel with carbon, which results in case hardening on subsequent treatment.

Cyaniding forms a hardened case which results from the absorption of carbon and nitrogen by the outer surfaces of the steel.

Nitriding is a treatment in which nitrogen is added to the surface of the steel to produce a hard case.

Hardening produces a hard martensitic structure by quenching a steel from above its critical range.

Selective Hardening usually refers to the hardening of only projecting ends or of sections of parts rather than the entire piece.

Tempering is a reheating procedure performed after hardening to provide stress relief and transform the hard martensite to a softer but tougher tempered martensite.

Stress Relieving, heating to some temperature below the critical range, merely relieves stresses set up in prior working or welding of the steel.

Austempering is an isothermal treatment (holding at a middle-range, constant temperature, rather than quench-and-tempering), which results in a Bainitic structure. Although Bainite is similar to tempered martensite, it is not the same in physical properties.

Martempering, another isothermal treatment, produces homogeneous, unstressed martensite. Tempering is necessary to produce tempered martensite for optimum physical properties.

Solution Treatment of austenitic steels consists of a heating to place undissolved carbides in solution and quenching to prevent their precipitation in grain boundaries.

What Production Schedule Must Be Met?

In selecting the proper equipment to meet a production schedule, the number of pieces, pounds or tons of material that are to pass through a unit each day or each hour must be known. Then, based on the heating capacity of a unit, the available space, and location of the available space, it is possible to select the equipment which will fill the production requirements.

What Equipment is Most Economical?

After the first two factors have been considered, the choice of equipment more or less tends to pin point itself on one or two of a few possibilities. At this time, a heat treater with a detailed knowledge of his own production requirements can consult with manufacturers' engineers who are familiar with the economic and metallurgical aspects of industrial furnace practice and finally be assured of making the proper selection of equipment.

The common theory that the lowest original cost and the lowest cost of operation and maintenance results in the most economical treatment set up is not always true. A better approach is to compute the cost of treatment per pound or per ton and thereby determine whether or not a higher original investment will prove more economical in the long run. It is only on this basis that automatically operated and manpower-saving equipment can be justified when costs are compared with conventional equipment.

Selection of Equipment

The factors shown below are important in selecting equipment that will fill a particular production requirement most economically.

Continuous or Intermittent Large Scale Production

1. Production Requirements (weight, sizes, length)
2. Quality of treatment desired
3. Available space
4. Location of available space (on or removed from production line)
5. Handling requirements
6. Heating capacity of units (temperature and load)
7. Heating Time (per batch, lot or individual piece)

Continuous or Intermittent Small Scale Production

1. Size, shape, weight and number of pieces to be treated
2. Quality of treatment desired
3. Heating capacity of the equipment (temperature and number of pieces)
4. Heating time (per piece or lot)

Heat Treating Methods

Basically heat treating is used either to harden or to anneal steel. All other treatments are some variation of these two types. Hardening is used to through-harden, case-harden or selective-harden steel parts. Annealing is fundamentally a softening process. The furnaces used to perform these treatments are usually designed for a specific treatment. This specialization arises from the trend in industry to make heat treatment an integral part of the production line by coordinating it with other operations. Annealing furnaces can be set up at one end of

a shop to soften steel for machining while units at the other end can be used to harden the finished parts. In a straight line flow of material such as this, the furnaces at any one location will rarely have to perform more than one or two related treatments.

Hardening and Tempering

The most common method of hardening steel is by the conventional quench and temper method. This method consists of heating above the upper critical temperature, usually to about 1650 F, and quenching in water or oil to produce a hard but brittle structure. Since brittleness in steels is an undesirable characteristic, the quenching operation is followed by a tempering treatment which consists of reheating to some temperature between 300 and 1200 F. Tempering changes the structure of the brittle steel so that it has an optimum combination of strength, hardness and ductility.

Electric and radiant tube gas fired furnaces of the continuous type are most commonly used for production hardening of bars, billets, tubes and similar products. These units have quench tanks and tempering furnaces arranged in order after the heating units so hardening and tempering can be accomplished with an uninterrupted flow of material. Induction and gradient heating units have similar set ups for hardening individual bars, billets and tubes. Electric and fuel heated rotary furnaces are suited for production hardening of parts that can be manually handled and tank or fixture quenched.

Batch or individual small part hardening can be done from electric or gas fired box or pit furnaces and lead or salt baths. Various mechanized salt bath accessory machines have made individual piece hardening possible on a production basis from these units.

Almost any type of furnace can be used for tempering because the treatment is done at temperatures under 1200 F where there is little or no decarburization or scaling. However, batch tempering is usually done in electric or gas fired, car, pit or box type furnaces.

Martempering and Austempering are two relatively new methods of through hardening by isothermal treatment. Both are based on the TTT curve and provide a rapid means for hardening with a minimum of distortion, warping and cracking. To date Martempering and Austempering have been done largely in salt baths because of the rapid heat transfer and accurate temperature control of these liquids. Isothermal treatments are usually limited to small parts.

Martempering consists of heating above the upper critical temperature and quenching in a molten salt which has been preset at a temperature just above the Ms point; the Ms point being that temperature for a particular grade of steel at which transformation in hardening first begins to take place. The steel is held in the bath just long enough to equalize the temperature between the surface and center after which it is withdrawn from the bath and air cooled. Since the hardened product is brittle, as in the quench and temper method, tempering is always necessary to obtain the desired combination of physical properties.

Austempering is performed by heating above the upper critical temperature and also quenching in a molten bath preset at a temperature just above the Ms point. However, the holding time in this case is not only long enough for the steel to equalize in temperature but also long enough for the transformation product at that temperature to form completely. The part is then air cooled but tempering is not necessary because the resultant product is similar to that obtained by the quench and temper method.

Case Hardening

Since many parts require only a hard, wear resistant surface, case hardening is a common treatment. Cases are formed by carburizing, cyaniding, nitriding and by surface hardening.

Carburizing is accomplished by heating steel between 1600 and 1850 F in the presence of a solid carbonaceous material, a carbon rich atmosphere or a liquid salt. Open fired or semimuffle gas furnaces are suitable for carburizing with a solid compound. Radiant tube and electric furnaces of the continuous type or electric and gas fired bell type furnaces have been designed for controlled atmosphere carburizing on a production basis while salt baths are particularly suited for carburizing small parts.

Cyaniding is done at temperatures of 1500 to 1650 F in salt baths, in electric or radiant tube continuous furnaces or in electric or gas fired bell type furnaces. For this treatment either a special salt or a controlled atmosphere can be used to impregnate the surface of the steel with carbon and nitrogen.

Nitriding consists of subjecting parts to the action of ammonia gas at temperatures of 950 to 1000 F to impregnate the surface with nitrogen. Generally the same furnaces are used for nitriding as for cyaniding.

Surface hardening is a relatively new method of case hardening. It results from the realization that hardness is entirely a function of carbon content and can therefore be applied to any steel which can be hardened; generally those steels with more than 0.35% carbon. This treatment consists of heating the surface of steel above the upper critical temperature to a desired depth and then water or oil quenching to produce a hardened case. Hardness gradually decreases from the surface to a depth of about 0.15-in. where the normal properties of steel still exist.

The development of surface hardening led to selective surface hardening in which different sections of the same part can be case hardened by applying a controlled heat pattern to the desired location and quenching. Selective hardening is especially important economically because it eliminates the need for complex heat treating cycles normally necessary to get some portions of intricately shaped parts hard and yet keep other portions soft.

A wide variety of induction, high gradient and flame hardening equipment has been designed for surface and selective surface hardening of gears, shafts, spindles, rotors and other intricately machined and forged parts.

Annealing

Steel is annealed to soften it for machining or fabrication, to relieve stresses set up in previous working, to alter physical properties through changes in structure or to condition it for subsequent heat treatments. Full annealing consists of heating to just above the upper critical temperature and then cooling very slowly through the critical range to permit the constituents to orientate themselves in their normal position within the steel. This serves to soften the steel and leave it stress free. Alloy steels with under 0.60% carbon are generally easily machined in this condition. Hard, elongated carbide particles tend to form in tool steels and the more

highly alloyed steels after working. These carbides make steel hard to machine; as a result a special spheroidizing treatment is necessary to eliminate them. Spheroidize annealing consists of heating to just below, just above or alternately above and below the lower critical temperature and holding long enough for the elongated carbides to break up into small globules or spheroids. In this condition the steel is easily machined.

While normalizing is not exactly an annealing treatment, it is closely related and produces much the same results as full annealing. The steel is heated above the upper critical temperature and cooled in air to let the structure of the steel normalize itself. This treatment is a conditioner for annealing and is used primarily to relieve structure variations and stresses set up in hot working. The same furnaces which are used for annealing can also be used for normalizing.

Electric and radiant tube furnaces have been designed for continuous production annealing while electric and gas fired pit, car, bell and box type furnaces are most used for batch treatment.

Bright annealing is similar to other annealing treatments except that the cycle is carried out in a controlled atmosphere to produce a bright, scale free surface. Electric and radiant tube continuous furnaces which operate with atmospheric control and bell type furnaces are generally used for this process.

Stresses in steel are relieved by heating below the lower critical temperature or below the tempering temperature of tempered steels. No changes in structure or physical properties are involved. Any furnace that can be used for annealing can also be used for stress relieving.

Cyclic annealing is a relatively new method of annealing. It is similar to austempering but instead results in a soft, annealed product because transformation takes place at a higher temperature. Steel that has been heated above the upper critical temperature is quenched in a molten salt bath set at a predetermined temperature. Holding at this temperature until transformation has completed results in the desired annealed structure and hardness. In this manner long furnace cooled annealing cycles normally requiring 18 to 30 hr. can be completed in from 4 to 7 hr. just by using suitable salt baths at fixed temperatures. Another advantage of cyclic annealing is that hot forgings can be taken directly from the press, cyclic annealed in a salt bath and thus save additional hours by eliminating the conventional slow cooling and reheating operations prior to annealing.

Salt baths are particularly suited for cyclic annealing of small parts while electric and gas fired pit furnaces are generally used for bars, billets and other large scale production parts.

The solution treatment of austenitic stainless steels of the 18:8 type differs considerably from the normal annealing procedure. These steels are not hardenable by heat treatment. The sole function of heating to from 2000 to 2200 F is to place undissolved carbides in solution so a subsequent water quench will prevent their precipitation in the grain boundaries. Carbide precipitation in grain boundaries causes intergranular corrosion in these steels.

Induction and gradient heating units as well as electric and radiant tube furnaces are especially suited for continuous tube and bar solution treatment while salt baths and electric or gas fired box type furnaces are used for smaller parts.

Equipment for Heat Treating

Gas and electricity are usually most economical sources of heat for heat treatment. Although oil works well for high temperature heating, it is not recommended as a general heat treating fuel because of its poor combustion at lower temperatures, its storage and handling problems and because it does not lend itself to precise automatic control as readily as gas and electricity.

Commonly used gases which are capable of heating efficiently in the heat treating temperature range of a few hundred degrees to 2400 F are coke oven gas, blast furnace gas, natural gas, propane and butane. Since gases can be kept under compression and easily piped to any desired location, handling and storage present no problem.

Electric furnaces using metallic resistors of the nickel-chromium or nickel-iron-chromium type have temperature limits of 1800 to 2000 F. For higher temperatures, such as used for hardening high-speed steel, carbon or silicon carbide resistors yield temperatures up to 2500 F. Because electric furnaces have no combustion products to partially protect the work from atmospheric air during treatment cycles, controlled atmospheres are used to prevent decarburization and scaling at temperature over 1200 F.

Electric and fuel fired furnaces can be divided broadly into two classes; those for handling work in batches and those for handling work in a continuous flow. Until a few years ago, most furnaces were of the batch type because of their flexibility, simplicity of construction and lower original and maintenance costs. However, recently the trend has been to coordinate heat treatment with other production operations through the use of continuous furnaces. The advantages of these furnaces are reduced handling of material, automatic control of equipment, and increased production through a continuous flow of material.

Gas Fired Furnaces

From the standpoint of heating principles, there are five types of gas fired furnaces; open-fired, semimuffle, full-muffle, high gradient and radiant tube. Whenever practical, air or gas recirculation is used to heat by convection as well as radiation.

Open fired furnaces are seldom used for any treatment other than carburizing because flames impinge directly on the metal surface causing local overheating, scaling and excessive decarburization. Since parts being carburized are surrounded by carbonaceous material in a container, the direct impingement of the flame on the container does not affect the parts. Carburizing time for medium and large size work is generally long, as a result the rapid heating rate and relatively high efficiency of open fired furnaces are useful for this treatment.

Semimuffle furnaces have the work elevated from the floor to permit un-

Special heat treating atmospheres can be made to perform a number of useful functions in addition to protecting surfaces of parts being heated. (Photo: Courtesy Westinghouse Electric Corp.)

derfiring which heats the work more uniformly than open fired furnaces and also protects the work from the direct impingement of the flame. Heating is by radiation from the walls and roof of the furnace and by contact with the products of combustion. Decarburization and scaling cannot be prevented in furnaces of this type because the only atmospheric control possible is adjustment of the air-gas ratio so that a slightly oxidizing atmosphere will exist. Semimuffle type furnaces are used for hardening, tempering, normalizing, annealing and stress relieving when a high degree of surface control of the steel being treated is not necessary. Most tool room gas fired furnaces are of the semimuffle type and are designed to operate in low, medium and high temperature ranges.

Full Muffle (bell type) furnaces are required for fuel fired equipment when the work is of such a nature that the work surface must be carefully protected. The muffle completely excludes products of combustion and makes atmosphere control within the chamber possible by introducing gases of the desired composition. Muffle furnaces are particularly applicable for normalizing, annealing, and hardening when decarburization and scaling must be avoided. The chief disadvantages of these furnaces lie in the longer heating and cooling cycles typical of batch treatment and lower heating efficiency resulting from the muffle between the work and the source of heat.

High gradient heating is accomplished by placing steel in a furnace preset at a temperature two or three times as high as the temperature to which it is desired to heat the steel. This method decreases heating time considerably. For example, if a 1-in. round bar is heated in a furnace set at 1600 F, the bar will still be approaching the furnace temperature after 8 min. whereas if the same bar were placed in a high gradient heating unit set at 3000 F, only 45 sec. is required to heat the bar uniformly to 1600 F.

Fast heating units such as these are used for annealing stainless steel tubes, bars and billets to 3 in. maximum dimension and for hardening, tempering, normalizing, annealing and stress relieving various grades of alloy steels.

Continuous high gradient heating equipment consists of a number of 1-ft. I.D. by 3-ft. long units in line depending on the maximum length of material to be treated. The work passes through the heating furnaces on a roller system at a rate of speed dependent upon the work size and the temperature of the furnaces. Valves and instruments which operate in conjunction with radiamatic pyrometers provide automatic temperature control in each of the furnaces. As the work leaves the last heating furnace it moves at conveyor speed into a temperature controlled high pressure water spray which produces the desired cooling rate and then into a series of tempering furnaces which operate on the same principle as the heating units.

Special equipment has been designed for surface hardening gears, cams, rotors, machine parts and similar products. One of the largest fields of usefulness for surface hardening, where the heat pattern can be controlled to the depth and contour desired, is in hardening gear teeth. Automatically operated equipment is necessary to obtain reproducible results on a sustained production basis. Most of these units are flexible and so designed that an easy adjustment can be made for successive batches of gears and other products of various diameters, widths and complexity.

Higher original costs and fuel costs tend to place limitations on high gradient heating. However, actual production results indicate an economy in heat treatment when gradient heating is applied within its limitations. Units are small, adaptable to existing and new production lines, automatically operated and controlled, and can treat individual pieces at a speed which can be coordinated with other operations.

Radiant tube gas heating was developed to prevent the products of gas combustion from reacting with the furnace atmosphere. Burners capable of providing temperatures to 3000 F are arranged to fire into tubes made of high nickel-chromium heat resisting alloys which are distributed along the furnace walls. Heating is totally by radiation, thus preventing the products of combustion from upsetting the chemical balance of the furnace atmosphere. Air can be recirculated in these furnaces to obtain heating by convection when treating light metals at temperatures below 1000 F.

Batch type radiant tube furnaces have been designed for carburizing, cyaniding, bright annealing, normalizing, hardening and drawing treatments in plants where the work to be handled and the space available is such that this type is essential. However, because

no muffle is necessary in radiant tube furnaces, they are particularly adapted to continuous units which assure an uninterrupted flow of materials and uniformity of treatment not readily obtained in batch type furnaces.

Another useful application of radiant tube furnaces is for carbon restoration to steel surfaces where previous hot work or heat treatment operations have reduced the carbon content below the desired limits. Using a controlled atmosphere of the desired carbon potential, carbon is transferred from the atmosphere to the decarburized steel surface. The process continues until a carbon balance is obtained between the atmosphere and the steel at which time the process stops automatically. No carbon is added above the initial amount established by the carbon potential of the atmosphere. Compared with the cost of metal losses in eliminating decarburization by machining or grinding to below the affected depth, carbon restoration presents an appreciable economy in time, material and labor cost.

Electric Furnaces

Electric furnaces heat by radiation from electrically heated metallic grids at various locations within the units. Absence of combustion products permits the use of controlled atmospheres which prevent decarburization and also find use for carburizing, nitriding, cyaniding or bright annealing. Most electric furnace equipment operates in the temperature range of 1800 F to 2000 F. Small box furnaces for hardening, tempering, normalizing and annealing are of this type; however, specially constructed box furnaces for hardening high alloy and high speed steels are capable of heating to 2500 F.

Pit furnaces are used for hardening shafts, tubes, barrels and rods which must be suspended during heating and quenching in order to minimize warpage.

Rotary hearth furnaces are usually loaded and unloaded manually. A circular hearth moves the work through zones of increasing temperature until the work reaches the desired heat. These furnaces provide uniform heating and cooling through automatic temperature control of heating zones and passage of work through each heating zone at a desired rate of speed.

Roller hearth furnaces are designed for high production. Sectioned off in heat zones, these furnaces can be used to heat bars, billets, tubing and strip for continuous normalizing and hardening. Racks for air cooling or quench tanks follow the last heat zone which is set at the normalizing or hardening temperature. Subsequent furnaces permit tempering of hardened products in an uninterrupted flow of material. Equipment similar to this type can be used for annealing by controlling the temperatures in the heat zones to provide the proper heating and cooling cycles.

Belt conveyor furnaces provide hardening on a medium or high production basis. They are particularly suitable for medium and small parts where nicking caused by dropping on the quench conveyor is not objectionable. These furnaces are usually equipped with either mechanical or manual charges and conveyor type quench tank so that handling is reduced to a minimum.

Pusher type furnaces are used in the production hardening of both large and small parts where nicking must be eliminated entirely or where quenching must be done in a fixed position to minimize warpage. The parts are manually loaded on trays, automatically pushed through the furnace and quenched. Both the conveyor and pusher furnaces are also suitable for annealing treatments.

Car furnaces are designed to facilitate normalizing or annealing of large heavy parts. The cars form the furnace bottom and travel in and out of the furnace on rails.

Bell type (full muffle) furnaces are especially suitable for annealing operations because of their exacting atmospheric control in which decarburization and scaling can be eliminated. Bell furnaces are also used for bright annealing coiled sheet, strip, wire and wire spools, tempering where work cannot be conveniently or economically charged in conveyor or pit type furnaces and case hardening such as carburizing, cyaniding or nitriding.

Induction Heating

An induction heating circuit is fundamentally a transformer wherein the conductor carrying an alternating current is a primary and the material to be heated is the secondary. The work piece is thus heated electrically by the alternating current, but does not come in contact with the power source. Heat is actually generated in the piece by eddy currents set up by its own I^2R loss, where I is the flow of current and R is the resistance to the flow of current. Since magnetic materials lose their magnetism at a temperature below those used for heat treating, the heat generated due to hysteresis is of negligible importance, and that resulting from eddy currents is the controlling factor. Therefore any material which is capable of conducting a current will become heated when placed within the confines of a conductor carrying alternating current.

High Frequency Equipment

There are three sources of high frequency current which find commercial use for induction heating. The first two, the motor generator and spark gap oscillator, are confined to the induction heating of metals. The third, the vacuum tube oscillator, is used for both induction heating and dielectric heating (where the nonmetallics are actually dielectrics of a capacitor circuit and the method of heating is classed as electrostatic).

Motor generator sets, commonly referred to as rotating equipment, are produced as standard units with up to 1500-kw. output and at frequencies of 960, 1920, 3000 and 9600 cycles per sec. Units such as these are powered by synchronous or induction motors operating at either 1800 or 3600 rpm. from standard 60 cycle power lines. Operating efficiency of motor generator sets runs generally at 75 to 80%, and since there is no power limitation, these sets can be used to harden extremely large parts. Of the three types of generators, the motor generator is commercially the most widely used because 95% of all induction heating problems can be solved successfully by the use of 9600 cycles or less.

Spark gap oscillator sets provide frequencies of 100,000 to 400,000 cycles and are rated at 7½, 15, 32 and 40 kw. input. The output from the largest machine is approximately 25 kw. which, therefore, generally limits this type of equipment to use on small parts if the heating time is to be kept low and full advantage taken of the high frequencies.

Spark gap machines are highly flexible and are easy to "tune" or adjust electrically to the work piece and the inductor. To a large extent this flexibility permits spark gap units to be set up readily for a wide variety of jobs. However, it is quite simple for these machines to produce the desired heat

in the work piece while being equipped with a badly applied inductor or while operating on detuned settings and thereby run up power costs and cause maintenance troubles. In the course of balancing themselves electrically to their work, spark gap machines average about 45% in efficiency.

Vacuum tube oscillators develop frequencies from 350,000 to 500,000 cycles with a few special units at 1,000,000 cycles. For dielectric heating oscillators running from 2 to 30 megacycles represent the major type of units. Efficiency is approximately 55%.

Larger units of both the spark gap oscillator and the vacuum tube oscillator types are on the market, but at a cost per kw. output so large and with space requirements so great in contrast to those of the rotating type that such equipment is not widely applied commercially.

All induction heating equipment consists of an inductor, quenching auxiliaries for hardening if needed, suitable transformers and capacitors, automatic timing controls and a high frequency generator. In addition, parts are handled intermittently or continuously depending on production requirements.

In making a study to determine the most economical heat treating methods for some 120,000 parts, one laboratory has found that less than 25% of the parts could be treated most economically by induction heating. Engineers who use the process find that from 20 to 30% of heat treating jobs are done best by induction heating. As a result it appears that roughly 25% of all heat treating operations fall within the induction heating field.

Surface Hardening

An unusual characteristic of high frequency heating, upon which surface hardening applications depend, is its tendency to concentrate on the surface of the conductor through which it flows. This phenomenon, referred to as skin effect, is a function of frequency and all other things being equal; the higher the frequency, the shallower the depth of penetration.

Because of its ability to control the areas to which heat is applied, induction heating is used to surface harden only the desired portions of shafts, intricately formed pieces such as rotors and crank cases, gear teeth, wearing surfaces of cams and similar parts. Often selective surface hardening can be substituted for carburizing where it is necessary to copper plate those portions of a part which are to remain soft.

Through Hardening

Two or more high frequency units sometimes are used in sequence for the continuous through hardening of tubes, bars, shafts and strip. The units may or may not be of different cycles, but quite often are of different kw. capacities. Usually the final temperature is reached only on the last inductor in line. A quench ring adjacent to the last unit provides the cooling medium, usually water at 55 F and 70 psi. pressure.

Annealing by Induction Heating

Induction heating is capable of annealing parts without decarburization or scaling because of its relatively fast heating. It is also used in the selective annealing of hardened parts, especially intricately machined work and heavy sections or thin sections which are integral with heavy ones. Selective heating eliminates the need to heat the entire part and often permits pieces to be made in solid forms instead of making several different pieces and then welding or brazing them together.

Economic Considerations

In view of the fact that induction heating equipment can vary in complexity, first costs can range from a few hundred dollars to over $500,000. An astonishing number of cases show that induction heating equipment costs seem to be just about in line with that of machine tools. That is, if $10,000 worth of automatic lathes or punch presses and dies were needed to fabricate a certain part, then $10,000 worth of induction heating equipment would be needed to handle the output. However, there is no logical reason for this comparison of figures on a dollar for dollar basis.

Of outstanding importance is the fact that the motor generator frequencies are obtainable at a lower cost per kw. than either the spark gap oscillator or the vacuum tube oscillator. This is especially true at low power rating and as the kw. output increases, the cost per kw. decreases with the motor generator unit, whereas it remains the same with the other two units.

From the standpoint of power consumption costs, it is more expensive to develop a Btu. of heat in a piece of metal with electrical energy than with gas or other types of fuel. However, higher production and lower labor costs have resulted in an overall treatment cost of $15.00 per ton for induction heating as compared with $30.00 per ton, a standard mill charge for heat treatment. These cost figures thus place induction heating in a favorable position as a method for heat treating steel when it is applied within the scope of its limitations.

Molten Bath Heating

Molten bath heating consists of heating metals and alloys by immersion in a bath of molten lead or molten salt. These molten materials heat by conduction and eliminate all contact of work with the atmosphere. Oil, gas and electricity can be used as sources of heat for both types of baths. However, lead baths are generally gas heated and the recent trend in salt bath heating has been toward the use of direct resistance electrode heaters.

Because of the characteristic fast and uniform heating without the presence of air, molten baths are particularly suitable for heat treating parts without distortion, warping, decarburization or scaling. Of course they have their limitations, but a recent survey has indicated that roughly 30% of all parts to be heat treated can be treated most efficiently and economically by using molten baths.

Lead Baths

Lead baths normally permit heating in the temperature range of 650 to 1700 F and therefore can be applied to a variety of heat treating operations such as normalizing, annealing, hardening, tempering and stress relieving which fall within that scope of temperatures.

The thermal conductivity of lead is greater than that of salts, although it is only above 1200 F that its heating efficiency actually exceeds that of salts, and then by a ratio of about 3:1.

Because of its high specific gravity, 10 as compared with about 2 for salts, metals float in lead; it is therefore necessary to provide some means to keep the work submerged in the bath during treatment. Probably the greatest difficulty encountered with the use

of lead as a heating medium is its affinity for oxygen and thus the ease with which it oxidizes. Lead oxide is not only injurious to the pot lining but also presents considerable difficulty when it adheres to the surface of the parts being treated and necessitates a troublesome cleaning operation. However, this trouble is usually held at a minimum by covering the lead bath with some carbonaceous material such as charcoal, coke or a charred material to prevent its oxidation.

Treatment from lead baths can be either on a batch or continuous basis. Batch treatment is usually performed in baskets while continuity of operation is obtained by a manual transfer of work into and from the baths.

Salt Baths

No one composition of salt baths is typical. These mixtures differ widely in composition and comprise hundreds of proprietary preparations, almost all of which are based on sodium and potassium chlorides and carbonates. Over all, salts heat from temperatures of 300 to 2500 F and can be divided broadly into three main groups which are determined by virtue of their useful temperature ranges.

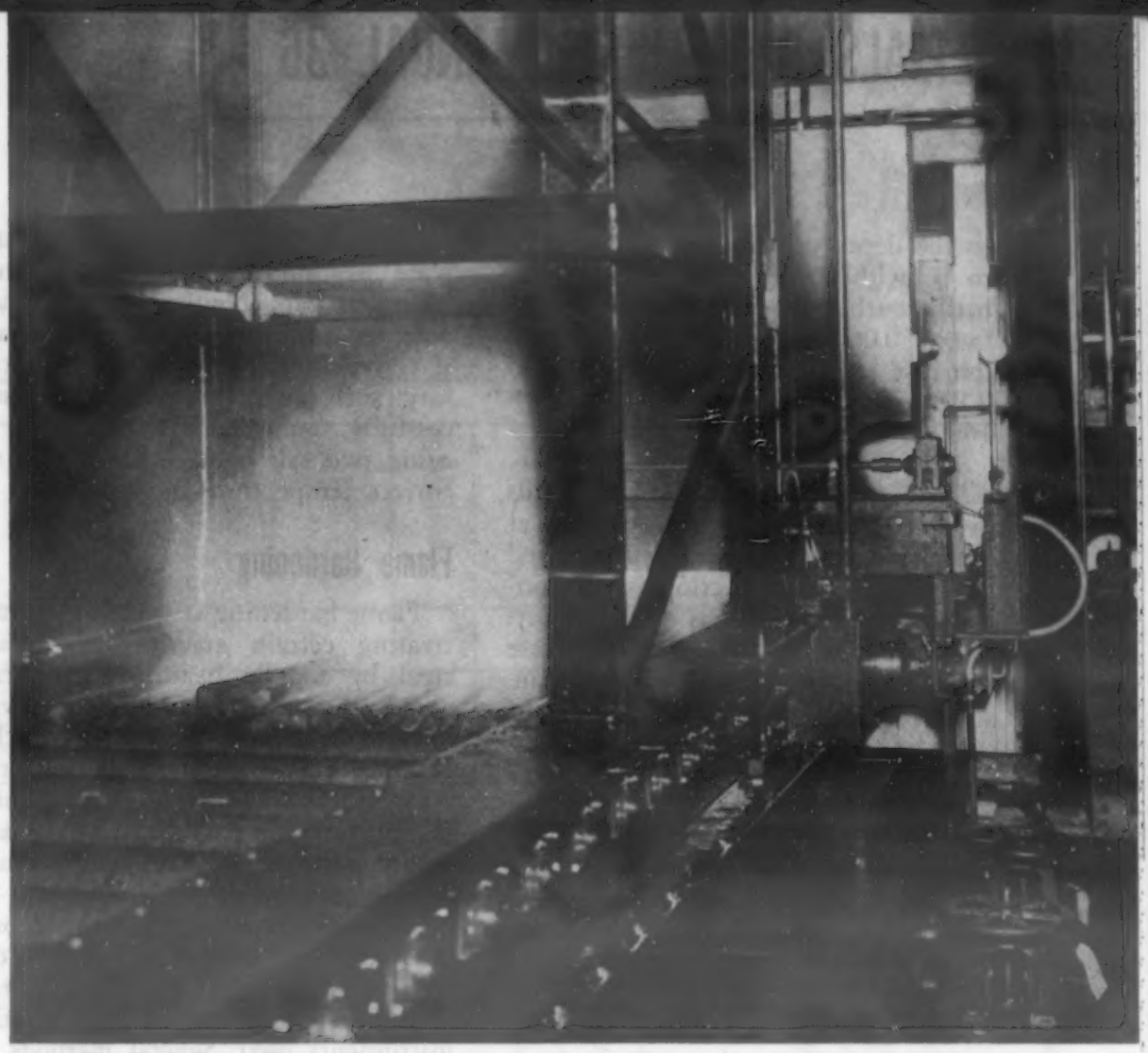
Low temperature salts which are used in the temperature range of 300 to 1000 F are primarily nitrates and nitrites. Useful applications of these salts include Austempering, Martempering and tempering steel.

Medium temperature salts operate in the temperature range of 1000 to 1750 F. These salts find application for the largest number of heat treatments among which are normalizing, annealing, quenching and tempering most of the carbon and alloy grades, preheating high speed steels, carburizing and cyaniding.

High temperature salts operate at temperatures from 1750 to 2400 F. These salts are primarily used for hardening high speed and similar highly alloyed steels.

Heat in electrode salt bath furnaces is generated by a group of electrodes, usually in pairs, which are immersed in the salt. A low voltage is impressed across the electrodes by means of a step down transformer so that an alternating current flows through the salt bath and heats it by virtue of its own resistance to the flow of current. Temperature variation can be maintained within 5 F.

Work is treated on a small production basis in salt baths to good advantage. However, numerous automatically operated and timed mechanisms have been developed to convey work through an entire salt bath heat treating process and thereby obtain the maximum productive capacity possible from the units. Such auxiliary equipment has important economic significance since the high original and operating costs of these furnaces are more than counteracted by the low cost per lb. of heat treatment by this method.



Large furnaces, such as roller hearths shown here, are usually restricted to high production jobs. The unit shown is receiving steel bars for tempering after the quenching cycle.

Heat Treatment

Any heat treatment operation which is performed at temperatures above 300 F and below 2400 F can be performed in salt baths with the exception of those annealing operations which by necessity must include controlled cooling cycles. In this case the same effect can be produced by cyclic annealing. Salt baths are particularly adapted to isothermal treatments such as cycle annealing, Martempering and Austempering.

Because of the rapid heating obtained by salt baths and because high speed steels suffer from grain coarsening with prolonged heating at high temperatures, salt baths have become the accepted method for treating these and similar grades of steel. The first furnace, or preheat furnace, is set at about 1550 F at which temperature the work is thoroughly soaked. After soaking, the work is transferred to a high heat furnace set at 2350 F and held just long enough to reach heat after which it is quenched in a salt bath set at about 1000 F and immediately double tempered at 1000 to 1050 F.

Case Hardening

Salt baths are useful for both through and case hardening of various grades of steels. The different types of case hardening are carburizing, cyaniding, accelerated cyaniding and nitriding. These treatments bear special significance because of the economy which can be realized by imparting a hard and wear resisting surface to a carbon steel rather than relying upon a more costly alloy steel to fulfill the same requirements.

Carburizing in molten salt baths

to the depth of 0.25 in. is considered to be within economical limits. Normally carburizing depths range between 0.060 in. and 0.100 in. with the case rarely made any deeper than 0.125 in. Temperatures range from 1600 F to about 1750 F.

Cyaniding is generally not considered to be economical for depths over 0.080 in. Baths are operated at about 1050 F and economy is affected considerably if production is not continuous and shut downs are necessary.

Accelerated cyaniding produces case depths from 0.030 in. to 0.060 in. within reason of cost. This type of cyaniding is carried out at temperatures of 1550 to 1650 F and produces a case generally lower in the nitriding and higher in the true carburizing quality than those obtained by plain cyaniding.

Nitriding is performed in baths at about 1050 F and economically produces case depths from 0.008 in. to about 0.015 in.

Economic Considerations

Many variables affect the relative merits of different types of heat treating equipment. In considering whether or not to install electric salt bath furnaces the following factors should be considered:

Costs, both initial and operating, tend to run high, but when comparison with other equipment is made on the basis of cost per lb., a real economy is found in many cases.

Productive capacity is very high in salt bath furnaces of proper construction with output being two or three times as much as for other types of equipment of comparable size and input.

Distortion is reduced to a minimum through methods of handling permitted by salt bath operation.

Surface protection is good. Work can be handled in properly controlled baths with no detrimental change in surface chemistry.

Temperature control is closer and more accurate than in other types of furnaces because of the heat transfer characteristics of the bath.

Production schedules—Salt baths are better adapted to continuous operations than to intermittent usage because of the difficulty in starting up after a shutdown.

Application—Salt baths are well adapted to the heat treatment of relatively small parts and tools but are not particularly applicable to large scale heating as for large forgings, billets or bars. Neither are they suitable for annealing of machined parts if conventional slow cooling is necessary; such parts, however, can be successfully annealed isothermally by using two salt baths operating at the correct temperatures.

Flame Hardening

Flame hardening is a method of heat treating certain grades of iron and steel by rapidly heating the surface above the critical temperature with oxyacetylene flame and then quickly cooling or quenching the heated area. As a result of the transformation which takes place, the part treated possesses a hard, wear resistant case and a tough ductile core.

The degree of accuracy and reproducibility of results which can be obtained with flame hardening vary with the method, equipment and control instruments used. Several methods of hardening are in use commercially; the equipment used in each case may be nothing more than just a plain blow torch and a bucket of water or an electronically controlled automatic machine with a conveyor type quenching mechanism.

Materials That Can be Flame Hardened

Generally speaking, any grade of steel or ferrous material that can be hardened by normal furnace methods can also be flame hardened. Steels containing 0.35% carbon are hardenable, but better and more uniform results will be obtained if the carbon content is above 0.40%. Plain carbon steels are hardened satisfactorily where surface hardness alone is the primary requisite. However, medium carbon-alloy steels such as the nickel-chromium, chromium-molybdenum and the triple alloy steels are considered essential where, in addition to high surface hardness, the part must have high strength to resist stresses or shock loads that it may be subjected to in service. Cast irons can also be flame hardened, but best results are obtained when alloying elements such as nickel, chromium and molybdenum are present.

Flame Hardening Methods

There are four general methods of flame hardening in common practice. The easiest and most elementary is the *stationary method* which consists merely of holding an oxyacetylene flame over the part or area to be hardened until it has reached the quenching temperature and then quenching the part.

Spinning is confined to cylindrical parts. It is accomplished by arranging burners around the peripheral surface of the part to be treated and then revolving the part within this ring of burners at a definite rate of speed.

In the *progressive* method, the burner is moved along the surface to be hardened at a uniform rate of speed although in some cases it might be more desirable to hold the burner stationary and move the piece to be treated under the burner. Either way is satisfactory.

The *combination* method is, as its name implies, a combination of the progressive and spinning methods. The burner, or group of burners, are spaced around the periphery of the shaft in much the same manner as used for spinning. The work is then rotated at a given rate of speed and at the same time the burners are moved progressively along the work surface.

Application of Equipment

Various types of equipment have been designed to obtain more consistent results with flame hardening on a production basis. The methods described above are a basic means of applying heat to the surface to be treated. Some of the more complex equipment is capable of heating by all four methods. A typical example of equipment with productive capacity and a high degree of accuracy in treatment is the flamatic hardening machine which is completely automatic in operation. A gear is placed on a spindle between two flame heads. An electronic thermopile is located just above the gear. When a button is pressed, a pair of live electrodes ignite the flame heads; at the same time the gear begins to revolve. The thermopile picks up the heat energy radiating from the rotating work piece as it is being heated, and transmits the energy to a temperature recording and control instrument. When the surface of the gear reaches the preset temperature, the flame is extinguished, the spindle stops and the part is deposited in the quenching medium.

Other equipment not so highly

Guide to Selecting Heat Treating Equipment and Methods

The table shown below illustrates equipment and methods that can be used for heat treating steel products. Only the more common uses for the different types of equipment are presented although some have additional applications under special conditions.

	Hardening								Annealing							
	Through	Austempering	Martempering	Surface	Selective	Carburizing	Cyaniding	Nitriding	Normalizing	Full	Spheroidize	Bright	Cycle	Tempering	Stress Relief	Solution
FUEL FIRED OR ELECTRIC FURNACES																
Open Fired						x										
Semi Muffle (Box)	x					x			x	x	x			x	x	
Full Muffle (Bell)						x	x	x	x	x	x	x		x		
High Gradient	x			x	x				x					x		x
Radiant Tube	x					x	x	x	x	x	x	x		x	x	
Pit	x								x	x	x		x	x		
Car										x	x			x	x	
Continuous (Electric or Radiant Tube)	x					x	x	x	x	x	x	x		x	x	
INDUCTION HEATING																
Motor Generator	x			x	x											x
Spark Gap Oscillator				x	x											
Vacuum Tube Oscillator				x	x											
MOLTEN BATHS																
Lead	x				x									x		
Salt	x	x	x		x	x	x	x			x		x	x		x
Flame Hardening				x	x										x	
Controlled Atmospheres						x	x	x				x				

mechanized is useful for intermittent treatment of small quantities of different parts. Large forgings and castings or irregular parts which cannot be conveniently treated in furnaces are probably treated more economically by flame hardening than by any other method.

Another field in which flame treatment is finding use is in the low temperature stress relief of structures fabricated by welding. Portability of equipment in these cases permits relief of weld stresses in extremely large structures such as ships and in one case a 10,000,000 cu. ft. wet seal gas holder.

Economic Considerations

Cost—Practice has found that a fair estimate of flame hardening costs is based on figuring ¼ cu. ft. of each gas for hardening one sq. in. of surface to a depth of ⅛ in.

Production capacity with flame hardening equipment is limited except where automatic machines are used.

Distortion is held to a minimum because of the small area heated in relation to the mass of the part.

Temperature control varies from the crude technique in which it is at the discretion of the operator and depend largely on his ability and experience to the precise control of the electronic thermopile on the flamatic hardening machine.

Production schedules—Flame hardening is most applicable to intermittent operations. When batch or production treatment is necessary, some other method is generally better suited unless automatic flame hardening equipment can be used.

Controlled Atmospheres

Controlled atmospheres are an integral part of heat treatment particularly because of their ability to regulate surface carbon. Most metals oxidize when heated in the presence of air causing decarburization and scaling. By the proper selection and control of furnace atmospheres loss of surface carbon and sealing can be eliminated; by the carbon restoration process previously decarburized surfaces can be replenished with carbon to whatever carbon content desired. Case hardening treatments such as carburizing and cyaniding are also performed with gas atmospheres. The constant need for atmospheric control in heating operations makes the consideration of gas atmospheres economically important in the selection of equipment.

The most common constituents encountered in preparing atmospheres are nitrogen, carbon dioxide, carbon monoxide, water vapor, hydrogen, hydrocarbons and in some cases traces of oxygen. With the exception of molecular nitrogen, all of these gases react with steel. The manner in which the behavior of these gases affects steel can be summarized briefly: oxygen attacks steel at all temperatures, it also decarburizes; carbon dioxide at heat treating temperatures oxidizes and decarburizes, water vapor behaves in much the same way; dry hydrogen is a deoxidizer and mild decarburizer; moist hydrogen is a powerful decarburizer; carbon monoxide is a deoxidizer and, at low temperatures, a mild carburizer; methane deoxidizes, but its principal function is that of a carburizer at elevated temperatures; dry nitrogen is inert at all temperatures.

Controlled atmospheres are used with least difficulty in the bell type furnaces which, however, can be used only for batch treatment. In those shops where an uninterrupted flow of material is required, continuity of treatment can be obtained by controlling atmospheres in continuous electric or radiant tube furnaces.

Typical compositions of prepared atmospheres and their applications are shown in the tables below.

Composition of Prepared Atmospheres

Gas Constituents in Per Cent	Type of Atmosphere				
	No. 1	No. 2	No. 3	No. 4	No. 5
Carbon Dioxide	5.0	0.2	0.0	0.0	0.0
Carbon Monoxide	10.5	1.5	20.7	34.7	0.0
Hydrogen	12.5	1.2	38.7	1.2	75.0
Methane	0.5	0.0	0.8	0.0	0.0
Water Vapor	0.8	0.0	0.0	0.0	0.0
Nitrogen	70.7	97.1	39.8	64.1	25.0

Applications for Different Types of Atmospheres

Type	Metal to Be Treated			
	Low C Steel	Med. C Steel	High C Steel	Special Steels
1.	Bright anneal	Bright anneal, clean harden	—	—
2.	Bright anneal	Bright anneal, clean harden	Bright anneal, clean harden	—
3.	Carburize, dry cyanide	Carburize, carbon restoration, dry cyanide	Bright anneal, clean harden	—
4.	Carburize	Carburize, bright anneal, clean harden	Bright anneal, clean harden	Clean harden tungsten molybdenum steels
5.	—	—	—	Bright anneal stainless steels

Temperature Control

No discussion of heat treatment could be complete without reference to temperature control which is so closely associated with furnace design and treatment methods. Probably more rapid advancement has been made in pyrometry than in any field related to heat treatment. With each new heating process that has been developed and with each new furnace that has been designed a new advancement in temperature control has been incorporated until, at present, electronic devices automatically control an entire heat treatment process.

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NUMBER 158
April, 1948

MATERIALS: Plastics
METHODS: Testing

Quick Identification of Plastics

The problem of making a quick, tentative identification of a piece of a plastics material frequently arises in the plant, sometimes in connection with scrap reclamation, or with the need for determining the type of material in a product made outside the plant. When a part fails in service, and use of an unsuitable material is suspected, the ability to make a rough identification is helpful indeed.

The tests given here are sufficiently specific to make a tentative identification in the shop in most cases. They are not a substitute for a chemical analysis, and will not differentiate between several formulations of the same basic type of plastic. Confusing results may appear if the material is a copolymer, or if it is a blend of several plastic types.

It should be borne in mind that plastics materials as worked into finished articles are not simple chemical compounds. They are mixtures of a synthetic resin—the plastic itself—with a plasticizer to soften it to the desired degree, and, usually, a filler or a fiber to give it body, higher physical properties, or some other special property. Coloring, either a dye or a pigment, is usually present. All of these materials have some effect upon the tests given, and the plasticizer and filler, being present in substantial quantity, affect them considerably. To try to include the reactions of the wide variety of fillers and plasticizers would make this simple chart unusable for any but the trained chemist, so some of the more important effects of these ingredients are noted, and the remainder are not given.

The tests require no complicated apparatus, no knowledge of chemistry, and no set of chemicals. A bunsen burner, a pair of tongs or forceps, a glass stirring rod, and perhaps a small dropping bottle of 1:1 hydrochloric acid and another of a mixture of 1 part concentrated nitric acid and 3 parts concentrated hydrochloric acid will suffice.

A hot stirring rod pressed firmly against the sample will indent it if it is a thermoplastic resin, but will not soften the thermosetting resins. The odor rising from the resin while in contact with the stirring rod should be noted, and compared with those given in the chart.

A small strip or rod of the plastics material, about 3 in. long and perhaps ⅛ in. in dia., or a sliver of approximately these dimensions cut from a solid piece of the plastic, is held by one end with the forceps for the flame tests.

The sample is brought to one side of a bunsen burner flame, regulated to make it nonluminous, and is held just to the edge of the flame until it takes fire, or for 10 sec.

I. No flame is produced.
  A. The sample deforms slowly.
    (1) Caution—fumes are poisonous. Resin is not attacked by mixed HNO_3 and HCl. *Polytetrafluoroethylene.*
    (2) Hydrochloric acid odor. *Vinylidene chloride or vinyl chloride copolymer.*
  B. Retains shape; odor of formaldehyde.
    (1) No other odor. *Urea formaldehyde.*
    (2) Strong fishlike odor. *Melamine formaldehyde.*
    (3) Phenolic odor. *Phenol formaldehyde* (inorganic filler).

II. Burns, but extinguishes itself upon removal from flame.
  A. Green flame, yellow at top; odor of burning rubber. *Neoprene.*
  B. Yellow flame; ignites with difficulty.
    (1) Acrid odor; green spurts. *Vinylidene or vinyl chloride.*
    (2) Phenolic odor, with odor of burning wood or paper. *Filled or laminated phenolic resin.*
    (3) Light-colored smoke; odor of burned milk. *Casein.*
    (4) Black smoke; aniline odor. *Aniline formaldehyde.*
    (5) Sparks from flame of burning plastic; acetic odor. *Flame resistant cellulose acetate.*
  C. Blue flame; yellow tip; melts and drips; odor of burning wool; slowly soluble in HCl. *Polyamide.*

III. Continues to burn after removal from flame; flame examined for color during first second of burning.
  A. Burning very rapid; intense white flame. *Celluloid or cellulose nitrate.*
  B. Flame blue, yellow at top.
    (1) Fruity odor. *Acrylic.*
    (2) Odor of burning wool; resin slowly soluble in HCl. *Polyamide.*
    (3) Steady burning; melts and drips; drippings may burn; odor of rancid butter. *Polyvinyl butyral.*
    (4) Sparks produced; melts and drips; drippings may burn.
      (a) Rancid butter odor. *Cellulose acetate butyrate.*
      (b) Fragrant odor. *Cellulose propionate.*
    (5) Melts and drips; drippings burn; paraffin odor. *Polyethylene.*
  C. Flame yellow.
    (1) Sparks produced; melts and drips; drippings may burn; acetic odor. *Cellulose acetate.*
    (2) Gives off dense smoke, with flecks of soot in air.
      (a) Odor of illuminating gas. *Polystyrene.*
      (b) Acetic odor. *Vinyl acetates.*
      (c) Odor of burning rubber. *Butadiene or butyl rubber.*
    (3) Black smoke, without flecks of soot in air.
      (a) Material softens; rubber odor. *Natural rubber.*
      (b) Material does not soften, but liquid appears at surface; rubber odor. *Vulcanized rubber.*
    (4) Flame blue at edges.
      (a) Melts; drips; drippings may burn.
        (1) Burnt sugar odor. *Ethyl cellulose.*
        (2) Odor of rancid butter. *Cellulose acetate butyrate.*
      (b) Resin cracks and breaks. *Allyl ester.*
    (5) Ignites with difficulty; no drippings; bituminous or waxy odor. *Cold molded materials.*

Prepared by Kenneth Rose, Engineering Editor, from data supplied by leading plastics manufacturers.

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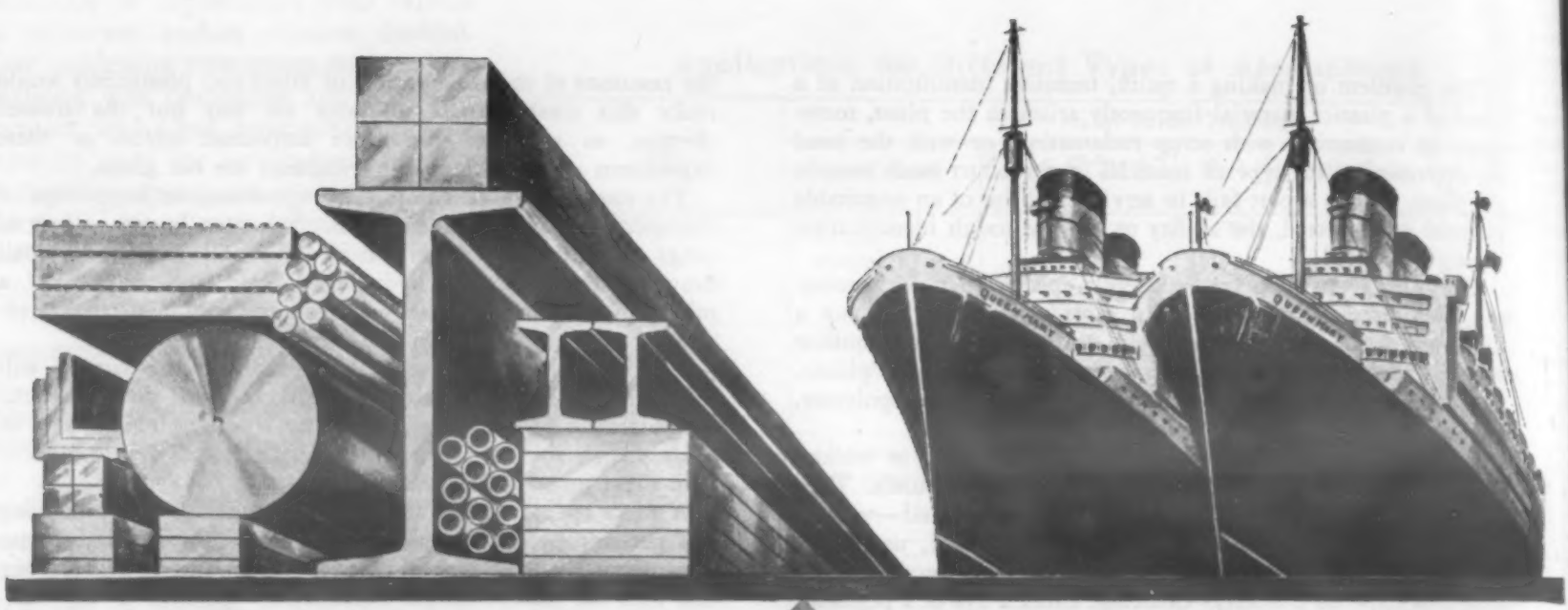

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B&W Junior Firebrick help you increase output and reduce costs by reducing the refractory replacement rate and by eliminating frequent furnace outages. Your local B&W Refractories Engineer will be glad to discuss your refractories problems.

R-304

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B&W REFRACTORIES PRODUCTS

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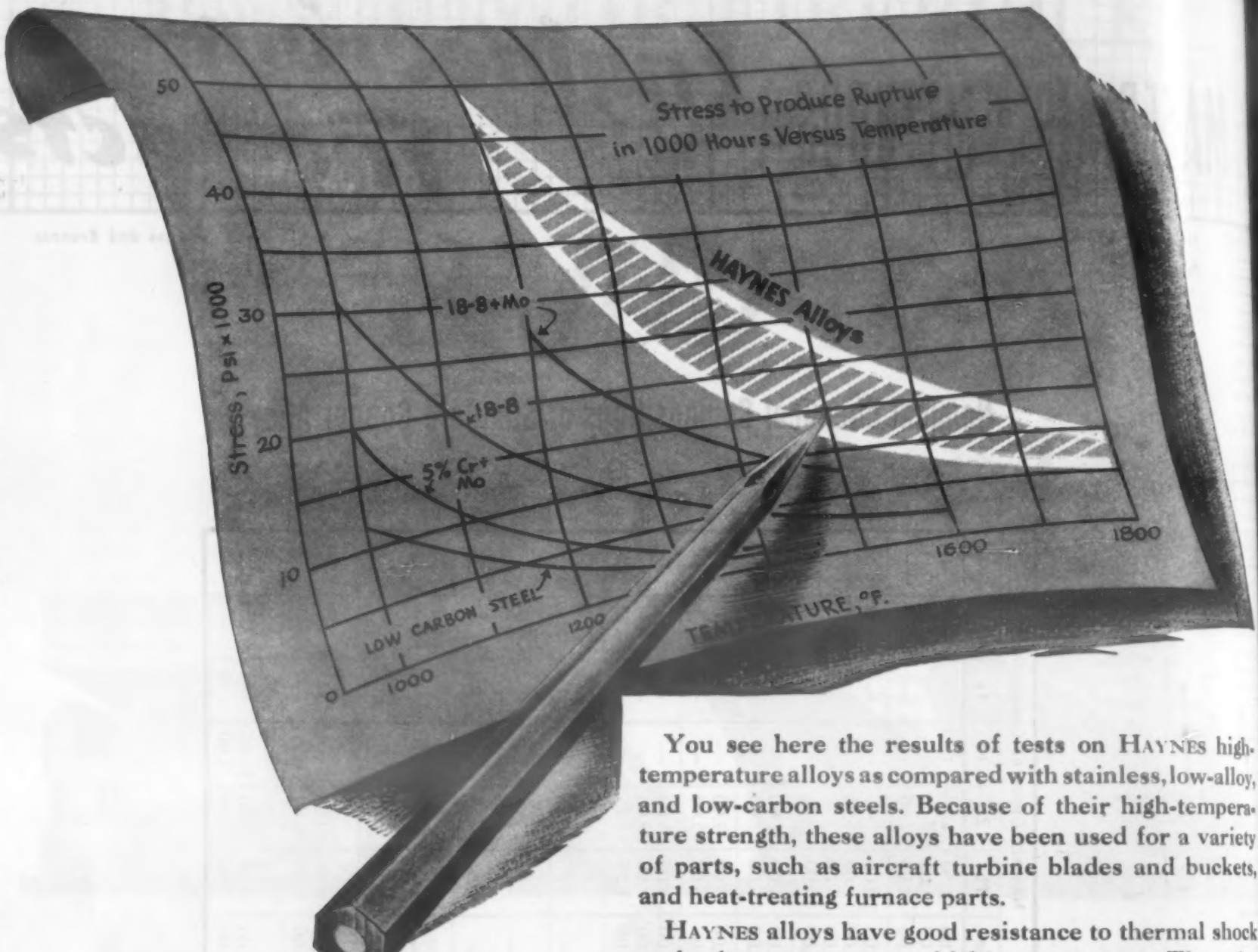
Nominal Chemical Compositions of Standard Copper Alloys

Classification	Alloy Number	Alloy Designation	Nominal Chemical Composition							
			Cu	Sn	Pb	Zn	Ni	Fe	Al	Mn
Leaded Tin Bronze	2A	88-6-1.5-4.5	88.00	6.00	1.50	4.50	—	—	—	—
Leaded Tin Bronze	2B	87-8-1-4	87.00	8.00	1.00	4.00	—	—	—	—
Leaded Tin Bronze	2C	87-10-1-2	87.00	10.00	1.00	2.00	—	—	—	—
High Lead Tin Bronze	3A	80-10-10	80.00	10.00	10.00	—	—	—	—	—
High Lead Tin Bronze	3B	83-7-7-3	83.00	7.00	7.00	3.00	—	—	—	—
High Lead Tin Bronze	3D	78-7-15	78.00	7.00	15.00	—	—	—	—	—
High Lead Tin Bronze	3E	70-5-25	71.00	5.00	24.00	—	—	—	—	—
Leaded Red Brass	4A	85-5-5-5	85.00	5.00	5.00	5.00	—	—	—	—
Leaded Red Brass	4B	83-4-6-7	83.00	4.00	6.00	7.00	—	—	—	—
Leaded Semi Red Brass	5A	81-3-7-9	81.00	3.00	7.00	9.00	—	—	—	—
Leaded Semi Red Brass	5B	76-3-6-15	76.00	3.00	6.00	15.00	—	—	—	—
Leaded Yellow Brass	6A	71-1-3-25	71.00	1.00	3.00	25.00	—	—	—	—
Leaded Yellow Brass	6B	67-1-3-29	67.00	1.00	3.00	29.00	—	—	—	—
Leaded Yellow Brass	6C	60-1-1-38	60.00	1.00	1.00	37.75	—	—	0.25	—
Leaded High Strength Yellow Brass (Manganese Bronze)	7A	60,000-15	—	—	—	—	—	—	—	—
High Strength Yellow Brass (Manganese Bronze)	8A	65,000-20	—	—	—	—	—	—	—	—
High Strength Yellow Brass (Manganese Bronze)	8C	110,000-12	—	—	—	—	—	—	—	—
Aluminum Bronze	9A	87.5-3.5-9	87.50	—	—	—	—	3.50	9.00	—
Aluminum Bronze	9B	89-1-10	89.00	—	—	—	—	1.00	10.00	—
Aluminum Bronze	9C	85-4-11	—	—	—	—	—	—	—	—
Aluminum Bronze	9D	81-11-4-4	—	—	—	—	—	—	—	—
Leaded Nickel Brass (Nickel Silver)	10A	57-2-9-20-12	57.00	2.00	9.00	20.00	12.00	—	—	—
(Nickel Silver)	10B	60-3-5-16-16	60.00	3.00	5.00	16.00	16.00	—	—	—
Leaded Nickel Bronze (Nickel Silver)	11A	64-4-4-8-20	64.00	4.00	4.00	8.00	20.00	—	—	—
(Nickel Silver)	11B	66-5-1.5-2-25	66.50	5.00	1.50	2.00	25.00	—	—	—

Data presented through courtesy of the Non-Ferrous Ingot Metal Institute, Chicago, Ill.



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MATERIALS & METHODS

DIGEST

A selective condensation of articles — presenting new developments and ideas in materials and their processing — from foreign journals and domestic publications of specialized circulation.

Edited by H. R. CLAUSER

Light Metals— Continuous Casting and Mold Steels

Continuous casting of light metals, when correctly done, is so advantageous and economical that, in England at least, it has largely supplanted other casting methods, according to W. Roth in the British magazine *Metal Industry*, Nov. 28, 1947.

Light alloy ingots and billets for extrusion and rolling should be of uniform composition and maximum density, as well as fine grained and free from nonmetallic inclusions. The article points out that only the continuous casting method fulfills all these requirements.

The economic efficiency of continuous casting is also important. With this method it is possible to cast direct from the furnace at a low and constant temperature. The process is capable of precise control within wide limits; thus, the rate of solidification and the shape of the solidification front can be regulated to any desired combination by varying the casting and cooling rate.

In addition to round, square and rectangular ingots, hollow ingots can be produced by the continuous process by the use of a water-cooled tapered mandrel. Clad billets for rolling can likewise be cast in composite form by the continuous process. Ingots from 1½- to 24-in. dia. have been cast continuously, although certain alloy types present difficulties at both extremes. Hollow ingots of 6- to 24-in. O.D. and 2- to 15-in. I.D. have been cast successfully.

An excellent detailed review of fourteen articles on permanent molds and die casting dies for aluminum is given in the French magazine *Fonderie*, Oct., 1947. The article rates the materials for aluminum permanent molds in the following order of increasing importance: (1) dense, ordinary gray iron; (2) heat treated 2% chromium cast iron; and (3) very homogeneous, inoculated cast iron.

For aluminum die casting dies, the order of increasing merit is: (1) a nickel cast iron with tungsten steel inserts; (2) a chromium-vanadium steel (this apparently refers to steels with about 0.35 carbon, 5 chromium, 0.25 to 1.0 vanadium and 1.25% molybdenum); and (3) a chromium-tungsten steel with molybdenum and high silicon, cobalt and vanadium optional (this seems to refer to steels with about 0.35 carbon, 1 silicon, 5 chromium, 1.25 tungsten and 1.5% molybdenum). Nickel may be added to the latter steel to reduce size change during heat treatment. Cores and pins for long runs should be made of an 18 to 22% tungsten steel with a small cobalt content.

Developments in Electropolishing

Electropolishing is relatively young and there are still a number of confused ideas about the process. For example, contrary to the opinion held by some, electrolytic polishing does not always produce a passive surface. Work by P. Locomb, P. Morize & G. Chaudron as reported in *Revue de Métallurgie* (French), Mar.-Apr., 1947, indicates that baths may be formulated that either will give oxide-free surfaces or will simultaneously polish and oxidize. Previous work has shown that practically oxide-free aluminum surfaces can be obtained by closely controlled electrolytic polishing. Their work extends to zinc and iron.

Polishing in a potassium hydroxide base electrolyte produced a simultaneous oxidation so that the zinc remained bright after long periods in humid air. Iron was much more susceptible to changes in polishing conditions than either aluminum or zinc. In most cases, the polished iron was covered with a protective film, but sometimes an oxide-free surface was obtained.

Further tests compared the activity of aluminum and zinc, as polished electrolytically and after exposure to air. The rate of corrosion of aluminum in 10 N hydrochloric acid is generally considered to depend on the purity of the aluminum. It was found, however, that the oxide film formed on contact with air was equally important.

Oxide-free aluminum was attacked immediately, while there was an appreciable incubation period for the oxide covered aluminum. This increased activity of the oxide-free aluminum was also observed in less corrosive media. Oxide-free zinc likewise showed much greater activity in various corrosive media than zinc exposed to air prior to corrosion.

Another development is the electropolishing of brass stampings, which has been explored in England by P. Berger and reported in *Sheet Metal Industries* (British), Dec., 1947.

After a number of tests with various solutions and operating conditions, he arrived at the following method: electrolyte: 70 to 90% water; 10 to 30% phosphoric acid; 180 gm. per l. chromic acid; 420 gm. per l. sodium dichromate; 80 to 95 gm. per l. sulfuric acid; 3 to 6 gm. per l. hydrofluoric acid; 80 to 150 gm. per l. propionic acid. Temperature: 60 to 120 F with 75 F optimum. Current density: 140 to 350 amp. per sq. ft. optimum. Electrode distance: 12 to 30 in. between electrodes with 20-in. optimum for maximum throwing power. Electrode area: ratio of cathode area to anode area under 1:1. Voltage: 14 v. average. Time of treatment: generally 2 to 7 min.

The process was put into production in 1945 and has proved very satisfactory. For parts to be subsequently bright nickel and chromium plated, a special neutralizing dip prior to plating was found necessary. The maximum uninterrupted flat area which will normally lend itself to production polishing was about 3 by 3 in. The rejects have been reduced from the initial 4% to about 0.8 to 1.25%. The process is not applicable to brasses that have more than 0.3% lead or tin.

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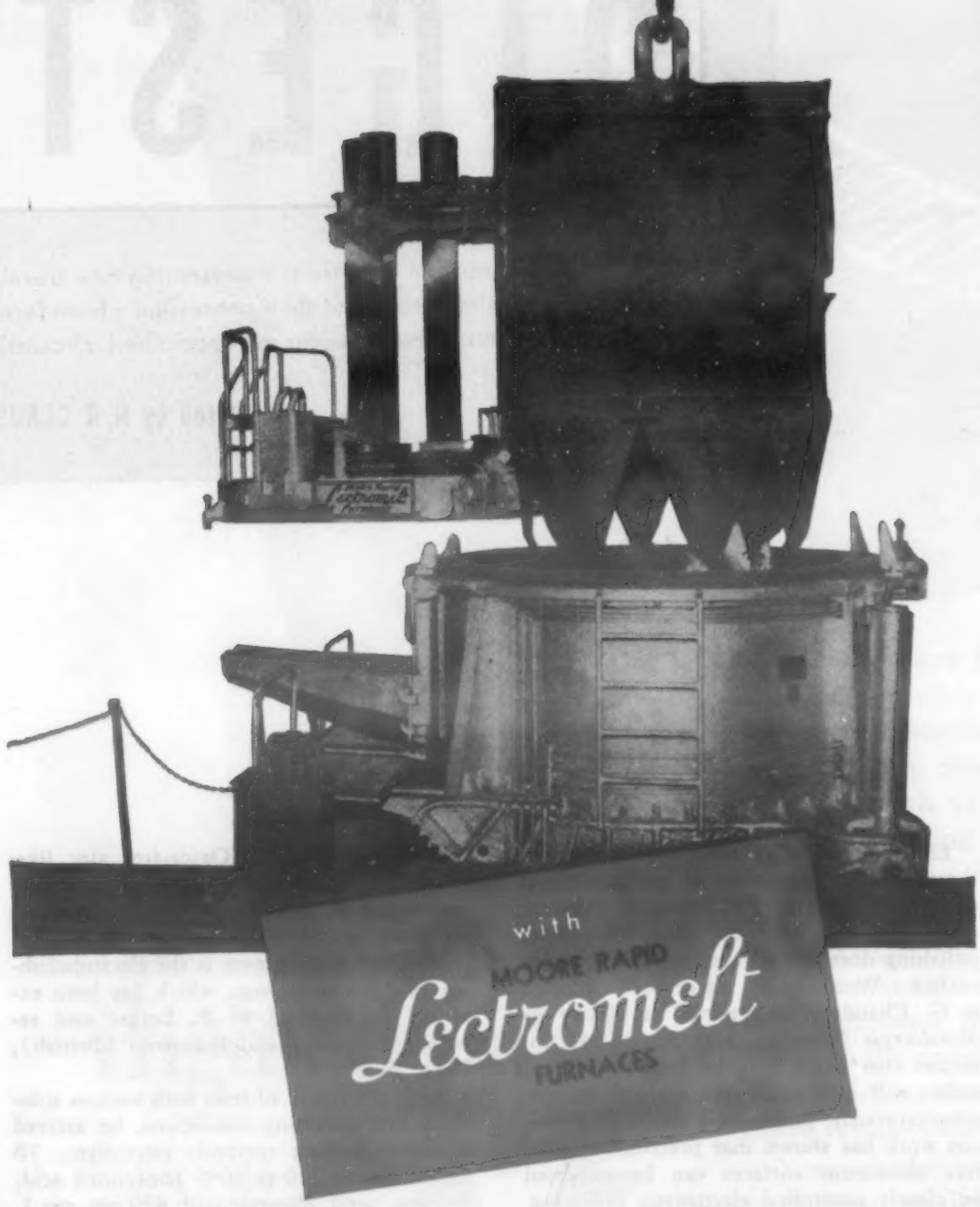

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DIGEST

Developments in Plastics

The National Annual Technical Conference of the *Society of Plastic Engineers* was held at Detroit in January, and at that conference a number of interesting papers were presented.

Advances that have been made in providing industry with polystyrene polymers and copolymers having greater versatility and wider fields of application was discussed in a paper by R. G. Fordyce ("Styrene Polymers and Copolymers for Industry"). The advances have been largely a result of improving the polymers and in developing copolymers that provide the plastics engineer with an increased range of properties.

In another paper, by L. E. Cheyney, recent developments in the field of plasticizers were covered ("Plasticizers in the Plastics Industry"). Plasticizers are used primarily for the purpose of imparting either temporary or permanent plasticity to the plastic mix. Many properties of the plastic, such as hardness, impact strength, flexibility, and electrical characteristics, can be varied widely by their proper selection and use. Recent developments in the field of plasticizers include the development of new flame-resistant materials, applications of polymeric materials as plasticizers and perfection of the paste technique of fabricating vinyl plastics.

One of the major problems facing the plastics industry today is the drop in the physical properties of plastics while in service. This problem has been investigated extensively, but mostly by empirical methods which consider over-all changes in one or more physical properties. Although investigations of this type give information of value, F. W. Reinhart advocates a new method of attack that will yield insight into the basic changes causing degradation in plastics ("A New Attack on the Degradation of Plastics").

The physical changes observed both visually and in tests result from changes in chemical structure of the resin and from loss or changes in the compounding ingredients. Thus, it is believed that for a satisfactory solution, it is necessary to determine the specific chemical reactions involved in the degradation of the plastic, and how these reactions are affected by the intensity of the conditions encountered.

Work of this kind is now under way at the National Bureau of Standards. Plastics are exposed to controlled conditions of heat, humidity, ultraviolet radiation, and ambient

DIGEST

atmospheres. The gaseous degradation products are collected and analyzed with the mass spectrometer. The changes in structure of the plastic are determined by studying such things as the ultraviolet absorption, infra-red absorption, X-ray diffraction, and dielectric absorption characteristics.

Development of high-speed aircraft during the past few years, requiring materials that will withstand the heat developed by airflow friction, has turned attention again to heat resistant acrylic sheet or Plexiglas. In addition, applications such as automobile visors, street and industrial lights, and washing machines have come along. In order to assist fabricators in the use of this material, O. L. Pierson described the latest techniques developed for heat resistant Plexiglas ("Fabricating of Heat Resistant Plexiglas").

He pointed out that many of the fabricating techniques used with regular Plexiglas are equally satisfactory with the heat resistant type. The major exceptions are in cementing and forming. Forming the heat resistant acrylic sheet also requires ovens operating about 25 F higher. These higher temperatures require more rapid handling during forming. In some cases heated molds have proved helpful.

New Theory of Recrystallization

A new theory on recrystallization and grain growth that may be of great assistance in indicating possible solutions to practical problems is presented by C. Peterson in the German *Metallforschung*, Oct., 1947. The theory assumes that the growth of a nucleus is caused by the elastic energy of a condition of hydrostatic internal stress in the nucleus. This localized stress is the result of the inhomogeneity of the plasticity of crystals and, particularly, of polycrystalline metals. This hypothesis seems to explain most recrystallization phenomena.

The effect of changes in single factors can be predicted in general from a table given in the article. Unfortunately, it is not possible to forecast the result when two or more factors are changed at the same time.

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DIGEST

the following conditions are favorable to the formation of a fine grain size on recrystallization: (1) an annealing temperature as high as possible with correspondingly decreased annealing time; (2) highest possible rate of heating; (3) a method of deformation as inhomogeneous as possible but not too non-uniform throughout the section (drawing in dies is better than unrestricted elongation); (4) lowest possible cold working temperature; (5) highest possible working temperature for the preceding hot working; (6) a rate of deformation as high as possible; (7) choice of suitable alloying elements (generally, very small additions are adequate); (8) an initial structure with a medium grain size; (9) previous strengthening by cold working is permissible if the final deformation is thereby further removed from the critical degree of deformation; and (10) recrystallization as soon as possible after cold working.

Corrosion Resistance of Nonferrous Alloys

Accelerated corrosion tests are always open to question until their relationship with actual corrosion in service has been proved. An interesting comparison of the results of short time water vapor tests at 200 F, weathering tests, total and alternate immersion in artificial sea water, and stress corrosion tests is given on a series of zinc alloys (with 4% copper; 4 aluminum and 1% copper; 32 aluminum and 3% copper) as well as brass and two aluminum alloys in an article by E. Gebhardt in *Metallforschung* (German), Oct., 1947.

Gebhardt found that there was no quantitative relationship between the results of the water vapor tests and those of the other corrosion tests. For example, in the water vapor tests, the corrosion of high aluminum zinc alloys increased with the amount of lead present. In atmospheric tests, however, as evaluated on the basis of loss of mechanical properties, the lead content (up to 0.8%) proved beneficial rather than deleterious. Moreover, the water vapor test

proved to be particularly severe for the zinc alloys. This test is considered useful only as an indication of corrosion resistance under tropical conditions.

The rating of the individual alloys in any specific test varied with the method of evaluation. Often the loss in weight, for example, gave an entirely different picture from the loss in tensile or impact properties. The results of the total and alternate immersion tests were, on the whole, in agreement.

The effect on corrosion of impurities in the high aluminum zinc alloys depended on the type of test and means of evaluation. The less pure alloys showed more corrosion in the water vapor test and in the atmospheric test as evaluated on the basis of weight change. The change in elongation and reduction of area, however, in the atmospheric tests were less than for the high purity alloys. In the immersion tests, the high purity alloys were again the least resistant. The heat treatment used to increase the strength of these alloys (water quench from 645 F with aging at 250 F) proved beneficial to the corrosion resistance, with the improvement in some cases more than 70%.

Effects of Impurities in Tin Bronzes

The general effects of impurities in bronze are known, but in view of the increasing contamination of scrap, more precise information is needed—particularly for chill-casting. In *Metal Industry* (English), Dec. 12 and 19, 1947, K. Winterton gives some pertinent details on the subject.

Among other things he states that zinc, aluminum, silicon and manganese have complex effects on the properties of bronzes. Due to the variation in two competing effects, greater deoxidation gives higher densities and improved elongation, while oxide films give opposite effects.

Antimony and arsenic cause weakening. Lead and bismuth have less effect on the elongation than antimony and arsenic. The effect of lead is less than that of bismuth. Nickel (up to about 1%) has very little effect. Iron in gunmetals and leaded gun-

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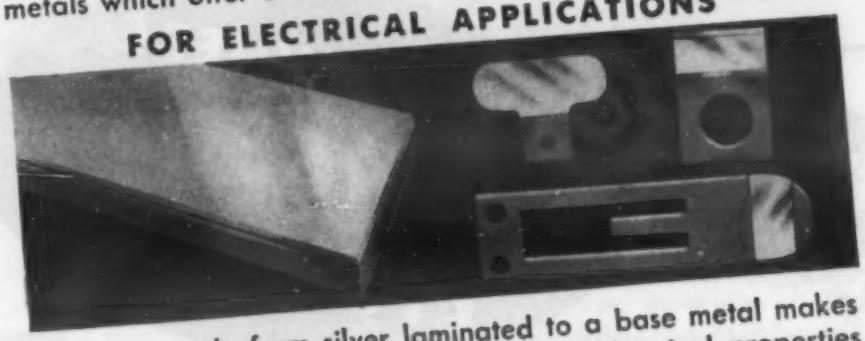

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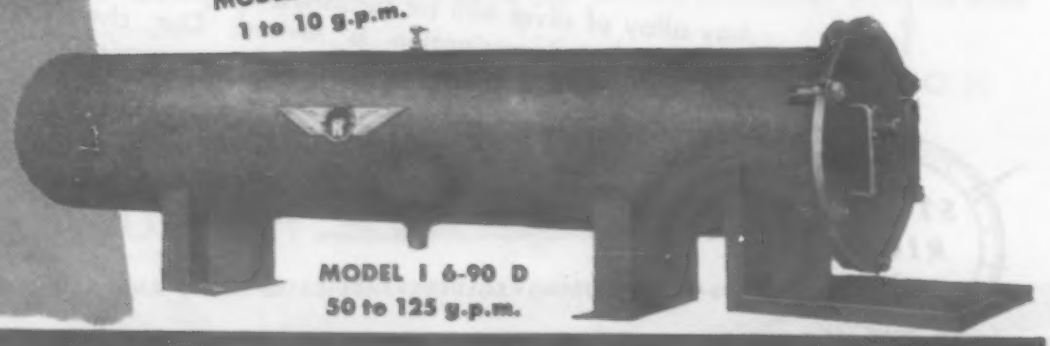

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DIGEST

metals reduces ductility but hardens the alloys.

If the disadvantages of reduced ductility and erratic hardness could be disregarded, iron could be used to strengthen certain alloys, particularly Admiralty gunmetal. Phosphorus has a beneficial effect on the properties.

Rapid Wetting Test for Solders

The tin shortage during the war, and still very much with us, required the use of either tin-free or low-tin content solders. To determine the wetting properties of these new solders, Bell Laboratories devised a simple test which is reported in their *Bell Laboratories Record*, Feb., 1948.

Twisted pairs of wires are immersed vertically in a bath of molten solder, which is held at a predetermined temperature. The height to which the liquid rises between the wires from the surface of the solder by capillary action in 15 sec. is observed. This height depends on the temperature and composition of the alloy, the diameter and thermal conductivity of the wires, their twist and cleanliness, the nature of the flux, and the time of immersion. By maintaining other factors constant, the variation in wetting ability as a function of any one factor can be readily determined.

Silver as a Contact Material

Silver, one of the widely used contact materials in electrical equipment, may actually be inferior to other materials for certain applications, according to B. W. Jones, speaking at a recent colloquium at the Massachusetts Institute of Technology.

The two most important factors in contact materials are thermal capacity and oxidation. It was pointed out that silver possesses the former characteristic in rela-

tively low degree. The resultant tendency to vaporize and explode when interrupting large currents may overshadow the superior life possibilities seemingly inherent in silver because of its low oxidation rate.

Oxidation is the important factor to consider when the contact materials will be used to make and break a moderate amount of power a large number of times, and thermal capacity is the factor that to a very large degree determines the life of contacts used for making and breaking a very large amount of power a few times. These facts were determined by a series of tests which encompassed a wide range of power circuits and operating conditions.

Electrodeposition of Tungsten Alloys

A method of producing satisfactory electrodeposits of tungsten alloys on metal surfaces has been developed at the National Bureau of Standards by A. Brenner, P. Burkhead & E. Seegmiller. The details of the process are given in Paper No. RP 1834, *National Bureau of Standards.* Deposits of tungsten alloyed with cobalt, nickel or iron have been obtained from hot ammoniacal solutions containing organic acids.

The maximum percentages of tungsten that may be obtained in this way are 35% in the nickel alloy, about 50% in the cobalt alloy, and about 60% in the iron alloy. However, for sound alloys of desirable properties, the tungsten content must be lower than the maximum.

The nickel-tungsten and cobalt-tungsten deposits have good adhesion to steel and can be plated up to a thickness of 0.02 in. without becoming appreciably nodular. The most interesting feature of the alloys is their hardness, which in the untreated nickel- and cobalt-tungsten alloys may be between 400 and 700 on the Vickers scale. The iron alloy is still harder, ranging from 700 to 900 Vickers; it is thus comparable in hardness to electrodeposited chromium.

Unlike most other electrodeposits, which soften with heat treatment, these alloys may increase 100 points or more in hardness upon heating to 600 F. The cobalt-tungsten alloy is of further interest in that it maintains a fair degree of hardness even at quite elevated temperatures.

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We specialize in cutting stainless steel plates by various methods. Our cutting equipment includes shears, abrasive cutters, band saws, hack saws and power cutting equipment, as well as numerous machine tools such as lathes, planers, boring mills, etc. By using these facilities we are able to provide you with blanks and patterns cut to your required sizes, for you to perform final finishing and fabrication work.

If it would be of advantage in your production to have Carlson's stainless steel plates delivered to you, cut to your layout, we would be glad to have you investigate the benefit of such action. Send us your specifications and blueprints on requirements for pattern cut sizes and blanks.

G. O. CARLSON, INC.

Stainless Steels Exclusively

200 Marshalton Road, Thorndale, Pa.

PLATES • FORGINGS • BILLETS • BARS • SHEETS (No. 1 Finish)

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If rust and corrosion eat into your profits by way of high maintenance costs and frequent replacements, look to the advantages of ARMCO Stainless Steels.

In the long run these rustless steels *cost less* than short-lived materials. Labor costs for repeat-installation jobs run high today—about 100% higher than 10 years ago. And the wholesale price index of materials has risen more than 80%. Yet ARMCO Stainless Steels have increased only 10% during that time.

60 Different Analyses

You'll find a type of ARMCO Stainless for practically all kinds of corrosion—from mild atmospheric to severe industrial. Grades range from 12% chromium types to those containing as high as 25% chromium and 20% nickel. (Armco produces more than 60 different analyses, and variations in all their mechanical properties and finishes add up to more than 500 possible mill routings.)

This means the right type of ARMCO Stainless Steel can solve most of your corrosion problems; but to make sure you get that right type always consult with our engineers.

The corrosion-resistance of ARMCO Stainless Steel is important in many *products* too. Stainless is easy to keep clean and new-looking indefinitely. And it helps make possible superior products that sell easier to more satisfied customers.

Prompt Deliveries

Write us, or get in touch with your nearest Armco Distributor. We can give you quick deliveries on practically all types of ARMCO Stainless Steel sheets, strip, plates, bars and wire. Just address The American Rolling Mill Co., 168 Curtis Street, Middletown, Ohio.

Export: The Armco International Corporation

New MATERIALS AND EQUIPMENT

Induction Heaters Boost Forging Efficiency

Forging bars that have cooled too much during the operation causes laps, cracks, and other rejectionable conditions. "Cold" forging usually is done because of the time lost in reheating; many operators do not like to lose several hours in reheating when a few more minutes work would finish a part.

The *Ajax Electrothermic Corp.*, Trenton 5, N. J., has just perfected a new self contained high frequency heater to reheat pieces the few hundred degrees required to bring them back to the proper forging temperature; it turns out one bar every 60 sec.

Bars 4 in. sq. and up to one yard long are heated to the forging temperature in an ordinary fuel fired furnace. Temperatures drop rapidly during forging. When the lowest permissible working temperature has been reached, the piece is placed in the induction heating unit located right at the forging machine. In a few minutes the part can be completed without having been worked below its minimum forging temperature.

This type of work station can be designed to fit practically any size job. Heating coils are easily interchanged when switching from one job to another. The capacitors are located in the bottom of the unit while the timers, contactors, etc., are in the space-saving overhead section.

Bars to 4 sq. in. can be reheated to forging temperature in units such as these at the rate of one every 60 sec.

Stress Relaxation Easily Measured In Rubber, Plastics

The Hi-Po-Log, developed by *W. S. MacDonald & Co.*, 33 University Road, Cambridge, Mass., is a compact instrument designed for accurate measurement of stress relaxation in rubber or plastic-like materials. It consists of a jig having a leaf spring as a platform above which is a cam-operated plunger which descends and compresses a sample placed on the leaf spring. Temperature compensated strain gages mounted on the underside of the spring transmit minute deflections to an electrical recorder.

The jig is located in a small temperature controlled oven above which is the recorder. Adequate space is allowed for temperature conditioning of a number of samples. The cam is operated manually by a lever which is outside the oven and located on the front of the case which houses the entire unit.

Samples can be loaded rapidly and the load adjusted through manipulation of a threaded plunger. The record of relaxation under the effectively constant deflection is continuous during the measuring time.

Heavy Duty Machines Do Multi-Spindle Honing

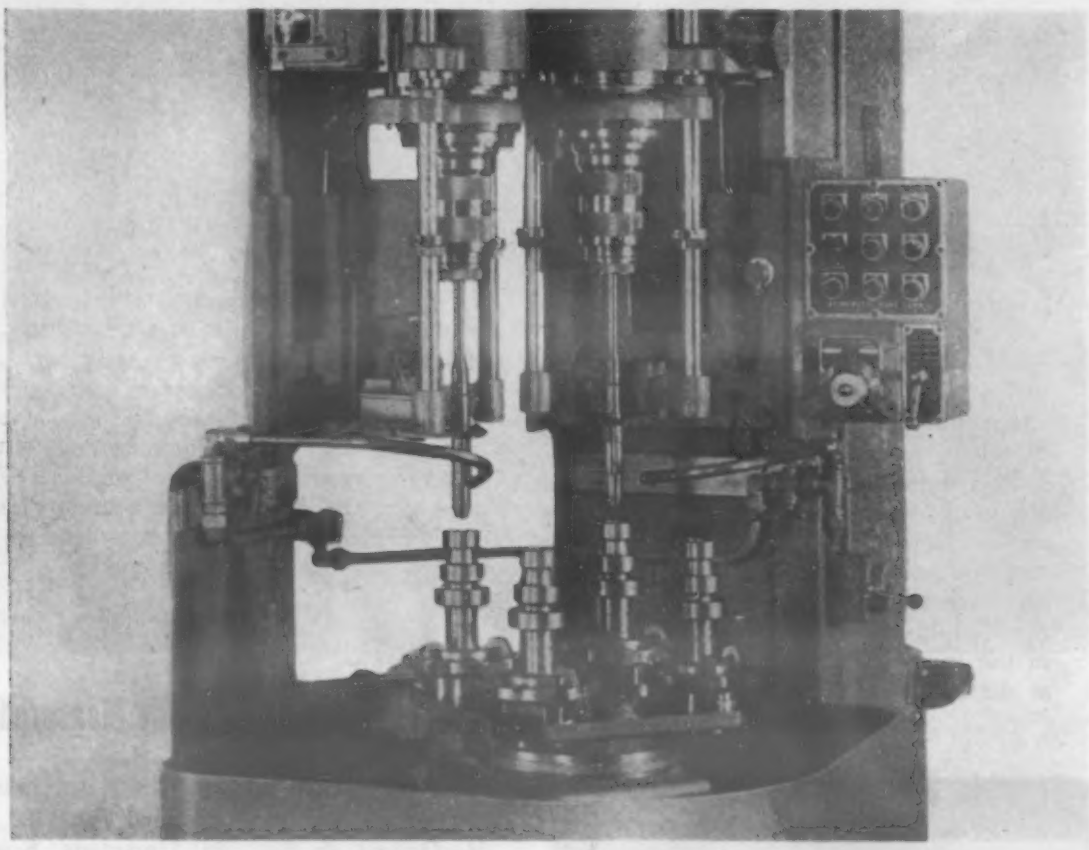
To meet the growing demand for automatic equipment that will remove more and more stock in less time from harder materials and hold closer tolerances, the *Micromatic Hone Corp.*, Detroit, Mich., now has available a new line of microhoning machines. These machines are heavy duty, multiple spindle, unit constructed Hydrohoners.

Microhoning is basicly a stock removing process. As the stock is removed the geometry, size and finish may be held to close tolerances. As the hardness of the material and the stock removal increase, the power requirements also go up and as the allowed tolerances are reduced, the adjustments and controls must be finer and more positive.

Multiple spindle, unit constructed, quill type machines give added power and control. The spindles are mounted in quills and each quill is actuated as an independent unit. This design is used to reduce the weight reciprocated to a minimum and to eliminate the necessity of guide bars. Torque and thrust are taken along the center line of the spindle.

Expansion of the tools and reciprocation of the quills are powered and controlled hydraulically. Feed-out is positive and the pressure applied in each tool may be adjusted independently.

Each quill is mounted on a separate column and columns are spaced about a common base and indexing table. By interlocking the hydraulic control panels, the automatic indexing table and the automatic sizing devices, the operation is made entirely automatic.



This machine is capable of removing 0.003 to 0.005 in. of stock from gears with a Rockwell C hardness of 58 to 60 at the rate of 200 pieces per hr.

Vapor Degreaser Cleans Steel

A vapor degreaser that was especially designed for small production degreasing operations is being made by the *Phillips Mfg. Co.*, 3425 W. Touhy Ave., Chicago 45, Ill.

This unit can clean over 400 lb. of steel per hr., removing all grease, oil and other contamination. Because of its light weight and small size, the degreaser can be easily located in any part of the plant where suitable electric power and water connections are available.

A pump attachment permits reclamation of soiled solvent by distillation within the unit while it is operating and without shutdown.

New Instrument Records Strains

A new Strain Amplifier, Model B1-310, designed for use with the Brush direct inking oscillograph has been announced by the *Brush Development Co.*, 3405 Perkins Ave., Cleveland 14, Ohio. With this instrument, immediate chart records of strain can be made with the Baldwin SR-4 Strain Gages. The equipment records either static or dynamic strains up to 100 cps.; and direction as well as magnitude of the measured strain can be read from the chart.

The amplifier contains two legs of the Wheatstone bridge network; the third and fourth legs are connected externally by the user, one being the active gage and the other for sensitivity doubling, or temperature compensation. Resistance and phase balancing controls are provided on the panel of the amplifier. Provision is made for connecting an internal calibrating resistor in the bridge circuit and adjusting the overall gain. The analyzer is readily calibrated for individual gages, so that strain can be read directly in microinches per in. from the chart deflection.

Although primarily intended for use with the SR-4 120-ohm. strain gage, this unit is also applicable for use with any resistance sensitive pickup. The instrument can be used to record pressures, temperatures, accelerations, forces, etc., provided the equipment is calibrated in terms of the particular pickup used.

Spectrometer Records Wide Mass Range

A recording mass spectrometer capable of measuring over the mass range from 1 to 350 and adjustable to any portion of that range has been introduced by the *General Electric Co.*, Schenectady 5, N. Y. This new instrument incorporates the control and stability features which have made the mass spectrometer a practical method for the chemical analysis of gases and vapors in the fields of atomics, nucleonics and ionics.

The mass spectrometer is applicable to general chemical analyses and isotope abundance measurements. It reduces the number of time consuming steps of complicated reaction and reduction processes to a single electrical separation with automatic recording of mass constituents in a few minutes time.

The instrument is built in two main units for easy inspection and maintenance. The control unit contains the electronic components and recorder, while the tube rack houses the spectrometer tube, vacuum pumps, gages, sampling system and additional components.

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4 TONS CARBON SHEET STEEL

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Specify—
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The "New Arithmetic in Steel" - makes every fourth part a Bonus part

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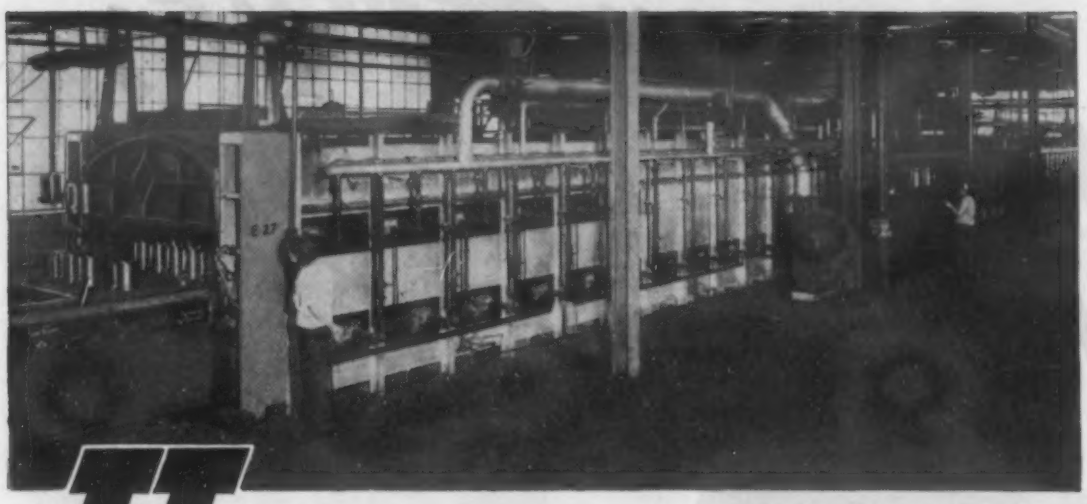


A side view of the Hagan Automatic Heat Treating Unit

Hagan *continuous automatic*

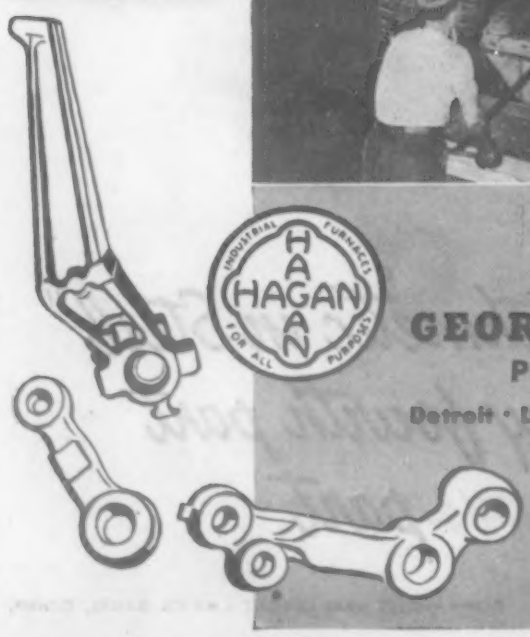
HEAT TREATING FURNACES

The Hagan Automatic Heat Treating Unit pictured above provides automatic movement of product through a hardening furnace—a completely automatic quench—and a draw furnace.

The product and treatment range of this unit is almost limitless since it handles irregular sizes, shapes and weights of forgings, either simultaneously or in sequence with uniform heat treating results. Carrier trays or fixtures are not quenched during the process. Labor requirements consist of only a two-man crew. Fuel can be oil, gas or electricity.

We'll be glad to discuss the application of these fully automatic heat treating principles to your requirements.

The discharge end of the Draw Furnace of the Hagan Automatic Heat Treating Unit showing the treated product emerging.



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Plastic Resin Strengthens Gypsum Plaster Castings

Plaspreg, a liquid furane resin impregnant, which will convert gypsum castings into hard, durable and chip resistant materials, has been introduced by the *Furane Plastics & Chemicals Co.*, 4500 Brazil St., Los Angeles 26, Calif.

This resin is prepared for impregnating purposes by mixing five parts of Plaspreg with one part of a special catalyst. After the catalyst has been added, the preparation must be used within a day or two.

Dry plaster castings, complete with all their decorative or design details, will readily absorb the resin which penetrates into the casting without obscuring surface details. Two- or 3-min. immersion is recommended for most small parts while brush application will prove more desirable for large parts.

The curing operation is best done in an electrically heated oven at a temperature range of 155 to 165 F for 18 to 20 hr. Heating and cooling cycles must be slow to prevent sweating out of the resin. Final cured forms are hard and scratch resistant.

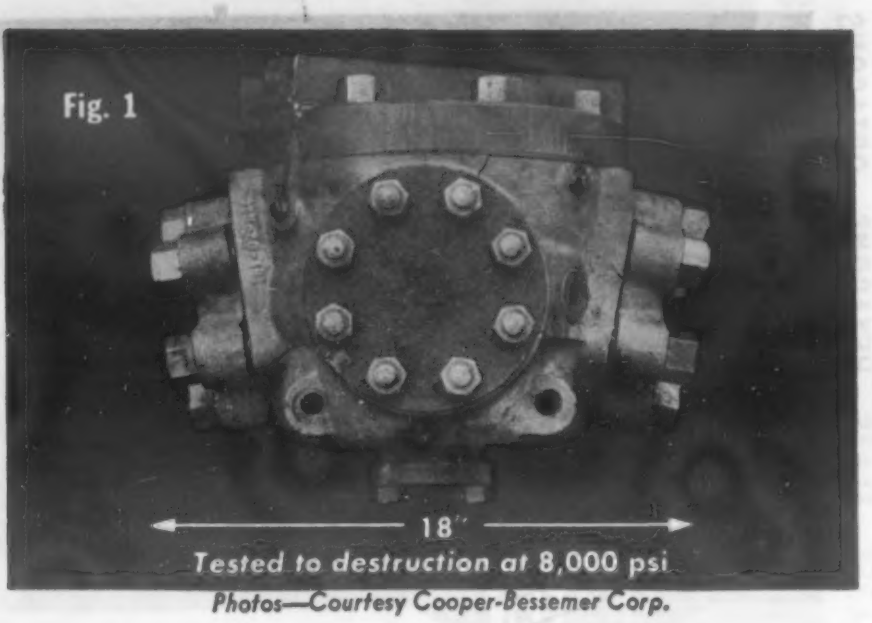
When parts come out of the curing furnace they appear dull and dark. An attractive finish can be obtained by buffing and polishing. A dark brown color is obtained by partial impregnation and a deep black results from full impregnation with Plaspreg. Light tan colors are made by using a Plaspreg bleach as the impregnating material. When lighter colors are desired, they may be applied in the form of lacquers and enamels which adhere satisfactorily to resin impregnated plaster without flaking or peeling.

Radial Relief Fixture Speeds Tool Grinding

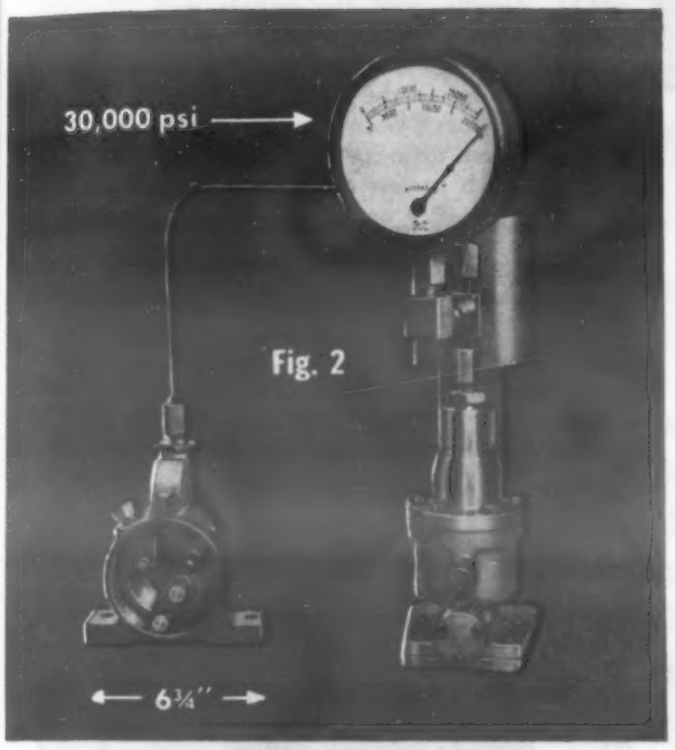
Perfection of a radial relief fixture by *Glenbard Tool Mfrs., Inc.*, 216 N. Clinton St., Chicago, Ill., now makes radial relief grinding of practically all types of tools possible. Heretofore, normal back-off grinding has been more prevalent because there was no practical machine fixture capable of handling virtually all types of cutting tools.

Advantages of radial relief cutting are derived from the fact that a minimum of stock is removed from behind the cutting edge, allowing adequate but only necessary clearance. By regulating the amount of relief, tools can be repeatedly sharpened while still adhering to the original specific tolerances. Finally, on those production jobs which can be accomplished in several grinding operations by the conventional method, considerable time is saved by using a radial relieved tool.

To Withstand High Pressures with...



Photos—Courtesy Cooper-Bessemer Corp.



Maximum Safety and Minimum Weight use MEEHANITE® Castings

A CASTING to provide true pressure tightness must be made from a metal which is uniformly solid through all sections, and free from shrinkage and porosity at change of section.

Meehanite castings are produced under methods which scientifically regulate these factors.

The illustrations above are two typical examples of pressure castings, one of which was tested to destruction. The compressor cylinder head (Figure 1) has a minimum metal section of 1″ and is designed for operating pressures of 1500 psi. Under test it took 8000 psi to fracture the unit.

The hydraulic pump head (Figure 2) is shown being tested under a pressure of 30,000 psi. At this pressure it was impossible to break the head. The casting has an average section of 1″ and did not fail under test.

Adequate safety factors are thereby provided without depending upon excessively heavy section thicknesses and resultant weights may be held to a minimum.

Thus the careful metallurgical and manufacturing controls exercised in the production of Meehanite castings are utilized to solve many of the difficult problems involving pressure tightness.

Write for Bulletin No. 10 "Meehanite — the Metal for Pressure Castings."

MEEHANITE®

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American Brake Shoe Co.	Mahwah, New Jersey
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Atlas Foundry Co.	Detroit, Michigan
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Barnett Foundry & Machine Co.	Irvington, New Jersey
E. W. Bliss Co.	Hastings, Mich. and Toledo, O.
Builders Iron Foundry Inc.	Providence, R. I.
H. W. Butterworth & Sons Co.	Bethayres, Pennsylvania
Continental Gin Co.	Birmingham, Alabama
The Cooper-Bessemer Corp.	Mt. Vernon, Ohio and Grove City, Pa.
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Traylor Engineering & Mfg. Co.	Allentown, Pennsylvania
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BILLETS AND FORGINGS FOR PRODUCTION, TOOL ROOM AND MAINTENANCE REQUIREMENTS.

"B" No. 3X ALLOY STEEL IS

6 ways better!

HY-TEN "B" No. 3X is the ideal alloy for heavy duty parts because (1) it is supplied in the heat-treated condition to your desired physicals (2) it is readily machinable at high degrees of hardness (3) high finish is obtainable with either ordinary high speed or carbide tools (4) scaling, distortion and straightening are eliminated (5) it often eliminates grinding (6) rehandling and added expense of heat treating are avoided. HY-TEN "B" No. 3X is available immediately from warehouse stock at short notice.

WL *steels are metallurgically constant. This guarantees uniformity of chemistry, grain size, hardenability—thus eliminating costly changes in heat treating specifications.*

Write today for your FREE COPY of the Wheelock, Lovejoy Data Book. It contains complete technical information on grades, applications, physical properties, tests, heat treating, etc.

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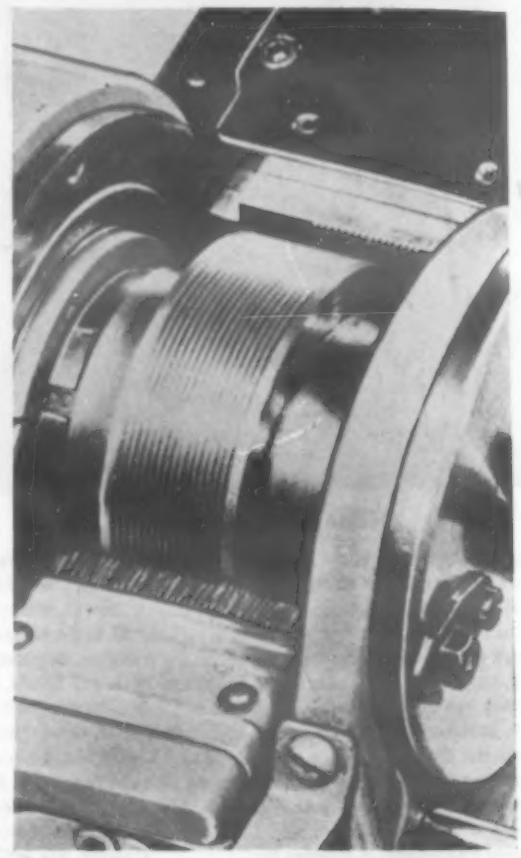
HY-TEN and AISI

Crushing Device Forms Cast Iron Rolls, Grinding Wheels

Cast iron rolls and grinding wheels are easily formed by a new self-truing motorized crushing device perfected by the *Sheffield Corp.*, Dayton, Ohio. This two-speed unit employs a carbide tool for dressing the form of a Meehanite or other close grained cast iron roll, which is then used to crush the grinding wheel without removing the roll. The device is designed for mounting on the table of an 8- by 24-in. or larger wet type surface grinder.

In cases of simple shallow profiles it may be possible to form the blank roll directly with the carbide tool. However, it is normally recommended that the roll be rough formed on a lathe and then finish formed in the crushing device. As the roll becomes worn from repeated grinding wheel truings, the operator just shifts the clutch to low speed and feeds the carbide



This motorized crushing device employs a carbide tool for dressing the form of a Meehanite or other close grained cast iron roll.

tool slowly into the roll until the original form is fully restored. This is accomplished within 3 to 5 min.

One of the chief advantages of this new crushing device is that all elements of the form are held precisely during the grinding of quantities of parts. This is especially important in grinding thread rolling dies, laminated sections, punch and die sections or any flat or cylindrical work of irregular contour.

The cast iron roll must necessarily be reshaved more often than a high-speed steel roll. Offsetting this, however, is the longer time needed to recondition a high-speed steel roll. Determining which type to use depends upon: type of profile and accuracy requirements, quantity of production, frequency of run, and facilities for reconditioning high-speed steel rolls.

First All-Welded Crankcase Reduces Costs 54% ...Improves Appearance

By M. V. Caldwell, President
Globe Mfg. and Compressor Co.
Battle Creek, Michigan

THE redesign of our air compressor crankcases was born of necessity. Past difficulties in obtaining parts of the conventional construction for the original design prompted us to convert to welded design and led to what we believe is the first all-welded crankcase used in the compressor industry. The changeover was accomplished gradually, one step at a time so as not to affect production schedules.

Fig. 1 shows the original construction of cylinder and crankcase assembly for our 20 C.F.M. air compressor. This unit had a total weight of 151½ lbs. and cost $29.57 for material and direct labor. In the first step toward welded construction, the lower crankcase only (Fig. 2) was welded and assembled to the cylinder and upper crankcase castings. The total weight of this design is 85 lbs., and its cost is $25.81 for material and labor.

Our success with the welded lower crankcase encouraged a further development shown in Figs. 3 and 4. This all-welded crankcase weighs 23 lbs. and costs only $13.76. A comparison of the original cost of $29.57 with this reduced cost of $13.76 represents an over-all production saving of 54%.

The component parts for the all-welded crankcase are fabricated from ⅛" and 3/16" sheared mild steel plate as shown in Fig. 3. The parts are clamped solidly in a universal jig for downhand welding, and then we weld inside and outside with 3/16" "Fleetweld 5" electrode using 300-amp. Lincoln "Shield-Arc" Welders.

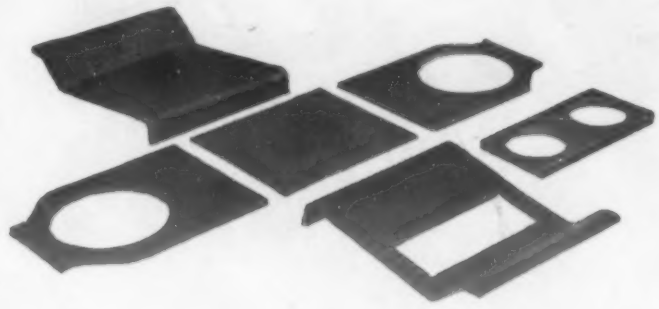
Several indirect benefits are gained with our welded design. In order to reach the required production, new and more elaborate patterns for grey iron would have been required at a cost of approximately $4,000 besides the expensive heavy fixtures necessary in machining the unwieldy cylinder casting. This cost has been avoided. In addition, an exceptionally high scrap loss, originally experienced in the lower crankcase, has been eliminated by the welded steel construction.

Savings made in weight are important to us because our selling prices are made f.o.b. the destination. Also reduction in base size from 20" x 26" to 16" x 22" is a great advantage in export shipping costs. Last, but by no means least, the welded construction simplifies painting and finishing to produce a more pleasing appearance and smoother finish.

Fig. 1. Cylinder and crankcase assembly originally used. Cost $29.57.

Fig. 2. Intermediate step in welded development. Welded lower crankcase assembled to upper crankcase and cylinders.

Fig. 3. Fabricated steel parts for all-welded crankcase.



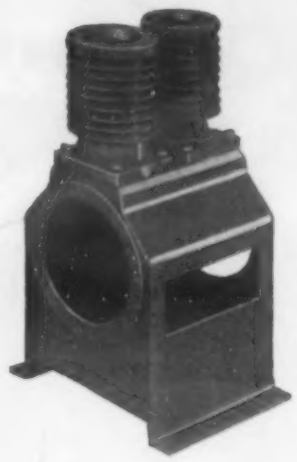


Fig. 4. Present all-welded crankcase and cylinder assembly. Cost $13.76.

The above is published by LINCOLN ELECTRIC in the interests of progress. Machine Design Studies are available to engineers and designers. Write The Lincoln Electric Company, Dept. 212, Cleveland 1, Ohio.

Advertisement

AW SUPER-DIAMOND FLOOR PLATE

GIVES YOU THE EXTRAS AT NO EXTRA COST

TODAY, stationary and mobile equipment designers and manufacturers are specifying AW Super-Diamond Floor Plate for all surfaces on their products, on which men walk or climb. The exclusive AW Super-Diamond Pattern provides *extra* safety for workers which ordinary floor plate does not offer. It grips without a slip preventing costly slipping accidents. It's extra economical—the first cost is low and there is no maintenance cost. Follow the example of leading designers and specify AW Super-Diamond Floor Plate for your products. Write for complete information, and a copy of our catalog.

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FLOOR PLATES THAT GRIP

Alan Wood Steel Company, Conshohocken, Pa.

Please send me a copy of your informative catalog L-51

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A Product of **ALAN WOOD STEEL COMPANY**
Other Products: Billets • Plates • Sheets • Carbon & Alloy

New Synthetic Rubber Has Better Physical Properties

A new synthetic rubber which possesses high tensile strength and low compression set after extensive immersion in fuels, oils and solvents has been announced by the *Felts Products Manufacturing Co.*, Chicago. This product, bearing the trade name Fel-Pro 131, has excellent durability through a wide temperature range, presenting flexibility with no cracking at –55 F and resistance to temperatures up to 300 F. A Shore "A" hardness of 80 is readily attainable.

Fel-Pro 131 finds unlimited uses for original equipment manufacturers of such products as automobile engine and chassis parts, pumps, freezers and refrigerators, high compression flanges and many other items employing rubber or rubberized sealing materials or parts.

● An entirely new procedure for the making of standard and special high-speed reamers, where the cutter blades of high cost, high-speed steel are firmly secured in recesses of a tool body of low cost low carbon steel, by means of a patented rolling process, is announced by the *U. S. Tool & Manufacturing Co.*, 6906 Kingsley Ave., Dearborn, Mich. It is an addition to their facilities for making high-speed steel cutting tools. This rolling process involves no application of heat as in welding or brazing, which deteriorates temper, hardness, and durability of cutter blades. Worn and undersized reamers can be re-rolled at the factory several times to restore the original diameter to precision limits.

Finishing Materials Protect Surfaces

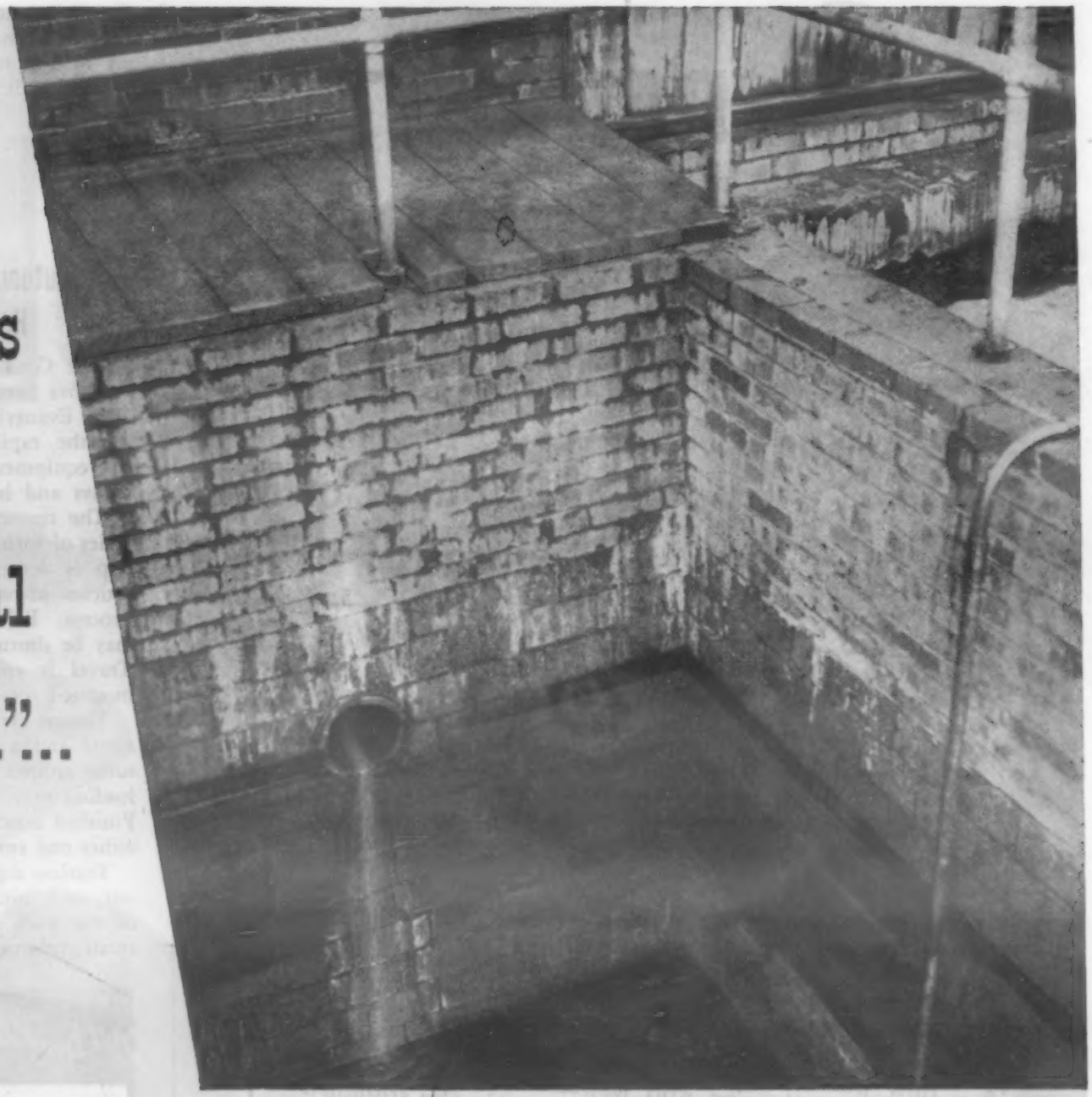
Surfaces of parts either being shipped or stored must be protected against corrosion and scratches. Two new materials have been developed to provide the necessary protection.

The *Stanley Chemical Co.*, East Berlin, Conn., is making Stantite, a rust inhibiting primer and preparation coating designed for use under air dried or baked finishes. This product has good adhesion to steel, stainless steel, galvanized iron, zinc, nickel, cadmium, brass, copper, aluminum, magnesium, glass and old finishes which are firmly attached to the base material. Stantite is particularly suited to spraying, brushing, or flow coating, but is not recommended for dip tank work.

The *Wyke Corp.*, 2214 Dolman St., St. Louis, Mo., has perfected a new plastic finish, Mirrofilm, which has passed a one-year outdoor weatherometer test without chipping, blistering, peeling, flaking or calking, and with retention of gloss. This

(Continued on page 130)

No ulcers in this industrial "stomach"...



Lined with acid-proof brick bonded with Pennsalt PRF Cement, the drain (upper right) and collection tank handle corrosive waste liquors for neutralization and disposal, at Allegheny Ludlum Steel Corp., Dunkirk, N. Y.

It takes a hardy system to "digest" waste pickle liquors like H_2SO_4, HCl, HF, HNO_3 together with caustic, alkalis and petroleum solvents all in one gulp!

Yet that's what this industrial waste tank at Allegheny Ludlum Steel Corp., Dunkirk, N. Y., has been doing for a year and a half. Maintenance? Nil. The Pennsalt PRF Cement joints are still in excellent condition, because PRF was especially designed to withstand the attacks of these chemicals.

Pennsalt PRF Cement is a resin-type cement, quick-setting, cold-hardening, easy to use. Thin joints (1/16" to 1/8") keep costs down. It bonds well with acid-proof brick, vitrified tile, carbon and Karbate brick, asphalt, wood, and—well, why not get the *full* story? Write for folder PRF 552—Special Chemicals Division, Pennsylvania Salt Manufacturing Company, Philadelphia 7, Pa.

Pennsalt PRF Cement helps protect waste pit for Allegheny Ludlum Steel Corporation

PENN SALT

Corrosion-Resistant Cements of many types for Acids, Alkalies, Solvents

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- Penchlor® Acid-Proof Cement
- Penchlor® Fire-Proof Cement

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  Primer and Clear Lacquer

Resin Type
- Asplit® Cement
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- Pennsalt PRF Cement
- Pennsalt PRFK Cement
- Pennsalt HF Cement
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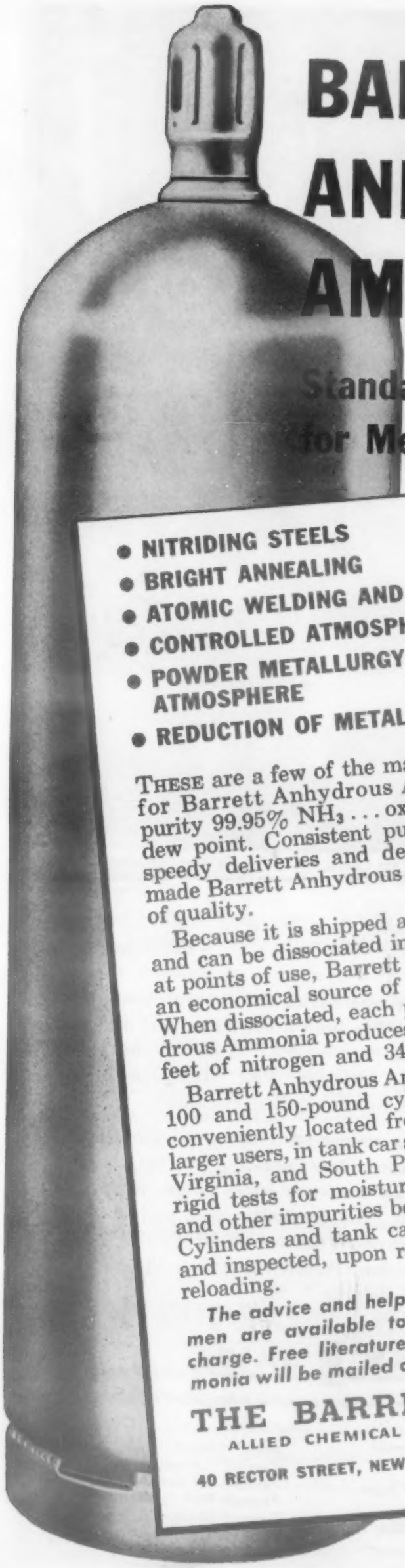


BARRETT ANHYDROUS AMMONIA

Standard Source of NH_3 for Metallurgical Uses

- NITRIDING STEELS
- BRIGHT ANNEALING
- ATOMIC WELDING AND BRAZING
- CONTROLLED ATMOSPHERES
- POWDER METALLURGY SINTERING ATMOSPHERE
- REDUCTION OF METALLIC OXIDES

THESE are a few of the many metallurgical uses for Barrett Anhydrous Ammonia—minimum purity 99.95% NH_3 . . . oxygen free . . . very low dew point. Consistent purity, uniform dryness, speedy deliveries and dependable service have made Barrett Anhydrous Ammonia the *standard* of quality.

Because it is shipped as a concentrated liquid and can be dissociated into its component gases at points of use, Barrett Anhydrous Ammonia is an economical source of nitrogen and hydrogen. When dissociated, each pound of Barrett Anhydrous Ammonia produces approximately 11 cubic feet of nitrogen and 34 cubic feet of hydrogen.

Barrett Anhydrous Ammonia is available in 50, 100 and 150-pound cylinders from warehouses conveniently located from coast to coast; or, for larger users, in tank car shipments from Hopewell, Virginia, and South Point, Ohio. It must pass rigid tests for moisture, non-condensable gases and other impurities before release for shipment. Cylinders and tank cars are thoroughly cleaned and inspected, upon return to the plant, before reloading.

The advice and help of Barrett technical service men are available to Barrett customers without charge. Free literature on Barrett Anhydrous Ammonia will be mailed on request.

THE BARRETT DIVISION
ALLIED CHEMICAL & DYE CORPORATION
40 RECTOR STREET, NEW YORK 6, N. Y.

Barrett

finish is useful for protecting metal, wood, linoleum and similar products. One coat of Mirrofilm, which can be wiped on, is usually sufficient for long protection.

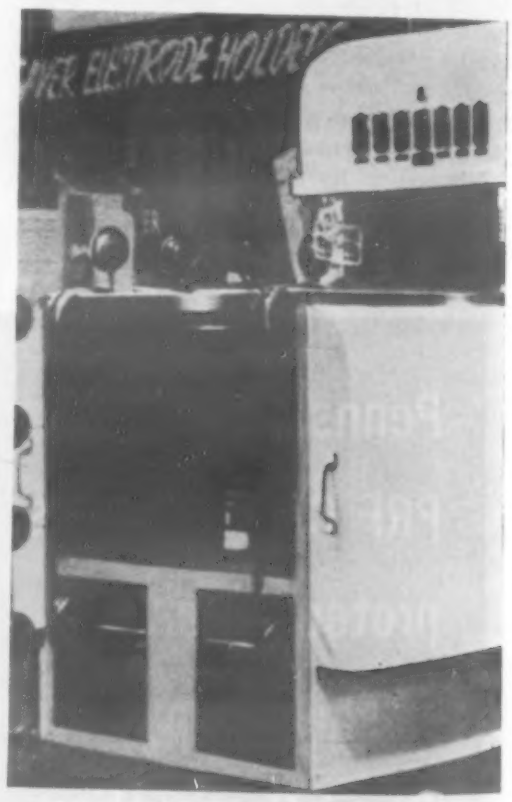
Automatic Finishing System Has Unique Features

The Gyra-Flow automatic finishing system has been developed by *George Koch Sons,* Evansville 4, Ind. Especially designed for the rapid production of small parts, the equipment washes, rinses, dries, dips, sprays and bakes in one continuous cycle.

The conveyor is a steel belt to which a series of spring type clips are fastened. Each clip is designed to support one or more articles of work through every successive process. Belts are joined by riveting and may be shortened or lengthened as desired. Travel is around a series of horizontally mounted rotating drums.

Timing is regulated by selective belt speed and a determined number of spiral turns around each drum. Loading and unloading may be manual or fully automatic. Finished articles are returned to stations at either end entirely without handling.

Tearless dipping is accomplished by flow-out, and initial set developed by gyration of the work after once passing through a small volume, level controlled paint dip



The Gyra-Flow automatic finishing machine washes, rinses, dries, dips, sprays, and bakes in one continuous cycle.

tank. Spraying may be electrostatic or automatic by using multiples of electrically operated spray guns exhausting into a water wash cabinet.

Any of the paints, varnishes, oils, enamels, sealers, shellacs or synthetics of the air drying or baking types may be used as finishing materials. Following this, the usual cleaning solvents and surface preparations are used.

Alloy Steels

Reduce Wear ... by providing extremely hard working surfaces —without sacrifice of strength or toughness

Anti-friction bearings are good examples of how Republic Alloy Steels can be surface hardened to resist wear—without any sacrifice of internal strength needed to withstand tremendous strain. Republic metallurgists have contributed much to the efficiency and economy of better bearings. And they are ready to work with you and your engineers toward improving your product.

Republic Alloy Steels offer many advantages—and one of the most important is *uniform* HARDENABILITY. These fine steels can be surface or deep hardened to *predetermined* values with full assurance of the results. Furthermore, the wearing surfaces produced are free from non-hardened or soft areas.

Such response to hardening treatment—plus retention of full strength and toughness—mean (1) less wear, (2) longer life and (3) lower cost for vital working parts when made of Republic Alloy Steels.

Republic—world leader in alloy steel-making—is well qualified to help you in selecting the most efficient alloy analysis for each use—and in fabricating and processing it to obtain best results. Write us.

REPUBLIC STEEL CORPORATION • Alloy Steel Division, Massillon, Ohio
General Offices, Cleveland 1, Ohio • Export Department: Chrysler Building, New York 17, N. Y.

Republic REPUBLIC STEEL
ALLOY STEELS

Other Republic Products include Carbon and Stainless Steels—Sheets, Strip, Plates, Pipe, Bars, Wire, Pig Iron, Bolts and Nuts, Tubing

QUICK QUIZ for ? PRODUCTION and QUALITY CONTROL MEN

(The Payoff shows up in Your Cost Sheets)

Q: How Can You

- *shorten or eliminate sizing and finishing operations?*
- *detect impending dimensional errors before they occur?*
- *sharpen cutting tools to get more consistent production?*
- *check surface roughness at the machine, in definite microinch units?*
- *save time and money on production jobs where successive sizing and finishing operations are required?*

A: Simply by using the Profilometer in your production department!

This simple, rugged shop instrument will measure the roughness of practically all machined or finished surfaces, directly in microinch units. The relationship of surface roughness to other gaging and control problems is such that, during the past ten years, the Profilometer has become a primary tool in quality control in leading plants throughout the country.

DETAILED ANSWERS to the above questions will be found in this illustrated bulletin, together with other facts of direct concern to production and quality control men. Write for a copy—and arrange to have the Profilometer demonstrated in your own plant. You may be surprised to learn how this instrument can cut your production time and costs.

The PROFILOMETER
TRADE NAME REGISTERED

PHYSICISTS RESEARCH COMPANY

ANN ARBOR • MICHIGAN

Industrial Lubricants Increase Operating Efficiency

The *Shell Oil Co.*, 50 W. 50 St., New York, has marketed a drill lubricator and a saw blade lubricant. The new lubricator is used principally with hand operated automatic drills up to ½-in. dia. A package is designed so that a rotating drill can be inserted through its top cover into the lubricant. This assures that metal chips will be kept out of the lubricant when the drill is inserted and surplus lubricant removed when the drill is withdrawn. The holder for the saw blade lubricant can be attached to a band saw guard to provide automatic, self-feeding lubrication.

The *Acheson Colloids Corp.*, Port Huron, Mich., has aided in designing a lubricant for press forging brass parts in deep impression dies. The lubricant is a special dispersion of semi-colloidal graphite supplied in concentrated form that is added to another fluid. Use of this lubricant results in better parting, cleaner and sharper forgings, improved surface finish, and longer die life.

G. W. Smith & Sons, Inc., 5400 Kemp Road, Dayton 3, Ohio, are making a new compound, Die Slick No. 4, for lubricating the pistons on cold chamber die casting machines. Because of its heat resistive qualities, this compound prevents all scoring and sticking of parts on which it is coated. Other recommended uses are for ejector and guide pins on pressure die casting dies; and for all movable parts of permanent molds.

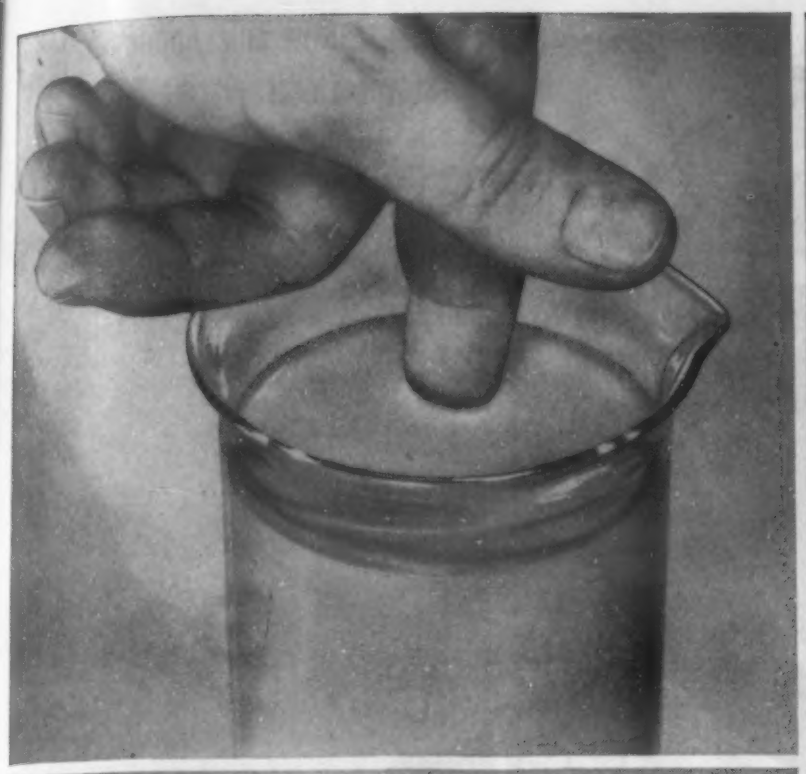
New Oils Are Water Soluble

Three new chemical esters that dissolve clearly in water have been made available in commercial quantities by the *Glyco Products Co., Inc.*, Brooklyn.

Chemically these products are polyoxyethylene oleates and laurates with a molecular weight above 800. All are nonionic, nontoxic, light in color, and fluid or grease-like in consistency. They dissolve clearly in water, alcohol, esters, hydrocarbons and vegetable oils. At 20 C they are slightly heavier than water. All have high boiling points and exhibit surface active properties.

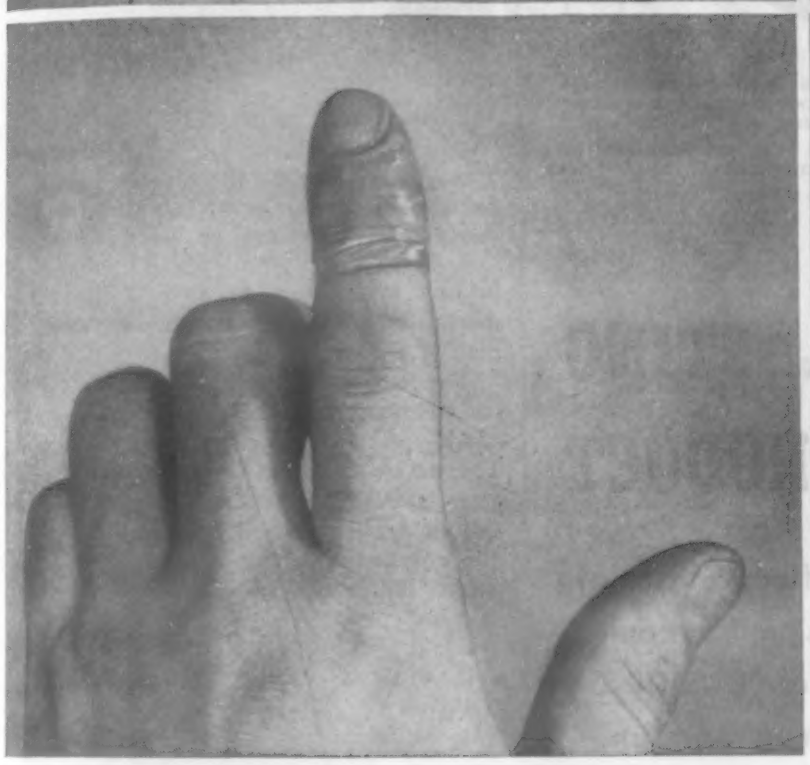
Recommended uses are as special detergents in textile and fiber processing; as penetrating lubricants; grinding media for pigments; plasticers for water dispersed products and water-insoluble resins, elastomers, plastics, coatings, etc.; and emulsifying agents for oils and hydrocarbons.

Trade names of these products are Polyethylene Glycol Mono Oleates (S1005 and S1010) and Polyethylene Glycol Mono Laurate (S1019).



Hot air not needed

A new Geon latex film-forming at room temperatures



THE man has just dipped his finger into a new Geon water-borne resin known as Geon Latex 31X. It will dry on his finger, in the air, at ordinary room temperature, rapidly and evenly.

If you package foods or deal in fresh fruits and vegetables . . . or if you're looking for a better adhesive . . . or want to make a water paint with a water-impervious film that will dry at simple room temperature . . . or if you're dipping toys, gloves, packages, etc., where the form has a complicated shape and a thin flexible wall or covering is required—you'll want to know more about Geon Latex 31X.

The deposited film is flexible, but contains no plasticizer. It is odorless, resistant to grease, and has low moisture vapor transmission. It won't support a flame. Adheres readily to paper, wood, fiberglas, and textiles.

A distinct advance, a cost-cutter, a product-improver, you will agree—and we'll be glad to send our special bulletin giving complete details. We make no finished products from Geon Latex 31X or any of our other raw materials. We are interested, however, in any problems or special applications. For the special bulletin, please write to Department U-2, B. F. Goodrich Chemical Company, Rose Building, Cleveland 15, Ohio.

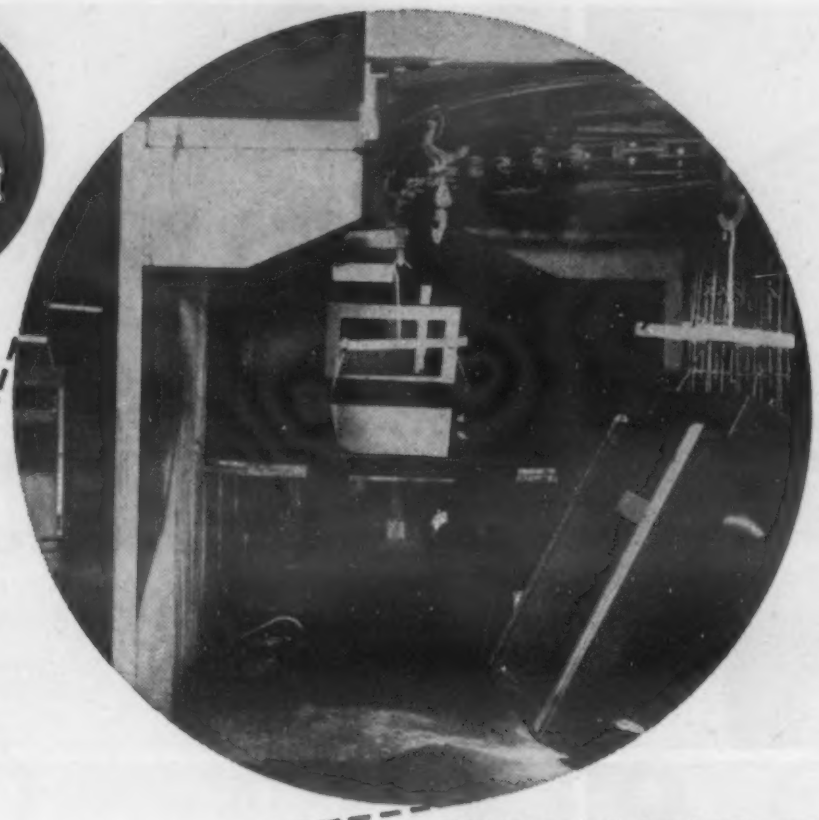
Geon
Polyvinyl Materials
A TRADE MARK OF B. F. GOODRICH CHEMICAL COMPANY

B. F. Goodrich Chemical Company

A DIVISION OF THE B. F. GOODRICH COMPANY

GEON polyvinyl materials • HYCAR American rubber • KRISTON thermosetting resins • GOOD-RITE chemicals

In the Spotlight



Right, foreground: Sheet steel electric range shells entering power spray washer to be cleaned and phosphate-coated with "DURIDINE".

Left: DURIDIZED shells, well conditioned for bonding paint, leaving washer.

Photograph courtesy of Hotpoint, Inc.

Duridize FOR A LASTING PAINT FINISH ON YOUR PRODUCT

CHEMICALS ACP PROCESSES

RUST PROOFING AND PAINT BONDING

Granodine *
Duridine *
Alodine *
Litholform *
Thermoil-Granodine *

RUST REMOVING AND PREVENTING

Deoxidine *
Peroline *

PICKLING ACID INHIBITORS

Rodine *®

Duridizing is very effective on all metals. The process is simple to control —uses a single chemical, "DURIDINE", which combines cleaning and phosphate coating—requires only mild steel power spray washers. Duridizing is equally suited to plants operating on full scale large production; and to plants faced with intermittent production.

"DURIDINE" is made, sold and serviced by a pioneer in the field of rust proofing.

Pioneering Research and Development Since 1914

AMERICAN CHEMICAL PAINT COMPANY

AMBLER, PA.

Manufacturers of Metallurgical, Agricultural and Pharmaceutical Chemicals

New Zinc Anode Solves Electroplating Problems

A new form of zinc anode has been designed by the *Wagner Bros., Inc.*, 422 Midland Ave., Detroit 3, Mich., to solve some of the common problems in electroplating. Referred to as "Flat Top" because of its shape, this anode is so distinctive in appearance that it cannot be accidentally confused with cadmium or tin ball anodes. Such confusions cause mixing of plating solutions and result in loss of time and materials from shut downs and dumping of plating tanks.

The characteristic flat top shape of the anode on the left prevents it from being mixed easily with cadmium or tin ball anodes.

The flat top shape is retained throughout the plating process so that a glance at the anode basket will identify the zinc tank. The anode's smooth surface is free from gates and flash which frequently cause ball anodes to hang on the basket wires, and the effective plating area is about 25% greater than a ball of like diameter.

General Purpose Heat Treating Furnace Developed

A new electric heat treating furnace that can be used for general purpose heat treatment and preheating high-speed steel has been made available by the *Stewart Industrial Furnace Div., Chicago Flexible Shaft Co.*, 5600 W. Roosevelt Rd., Chicago 50, Ill. Heating capacity for this furnace ranges from 400 to 1850 F, with heating elements on four sides of the chamber to assure close temperature control and even heat distribution.

Rolled nickel-chromium alloy ribbon is formed into continuous loops supported with insulators allowing free expansion and contraction. The ribbons can be replaced easily by removing door vestibule tiles.

A patented seal-tite door, which can be operated manually or by a foot operated air hoist, assures a tight seal between the door and the furnace at all times.

O'Sullivan ——— *"America's No. 1 Heel and Sole" selects*

PERBUNAN

Copyright 1948, Enjay Company, Inc.

BECAUSE ***"We tried every oil resistant material available and we found Perbunan could be finished to the right degree of hardness and still have sufficient high and low temperature flex resistance in presence of oil" . . . writes J. M. Mason, Vice President, O'Sullivan Rubber Corporation.***

BECAUSE with this new O'Sullivan line, working shoes can now have heels and soles that gasoline and oil *cannot penetrate*—as happens with leather.

BECAUSE Perbunan Nitrile Rubber will not deteriorate or swell after contact with gasoline or oil—as happens with natural rubber.

BECAUSE Perbunan heels and soles keep their safety-grip qualities *longer* than natural rubber.

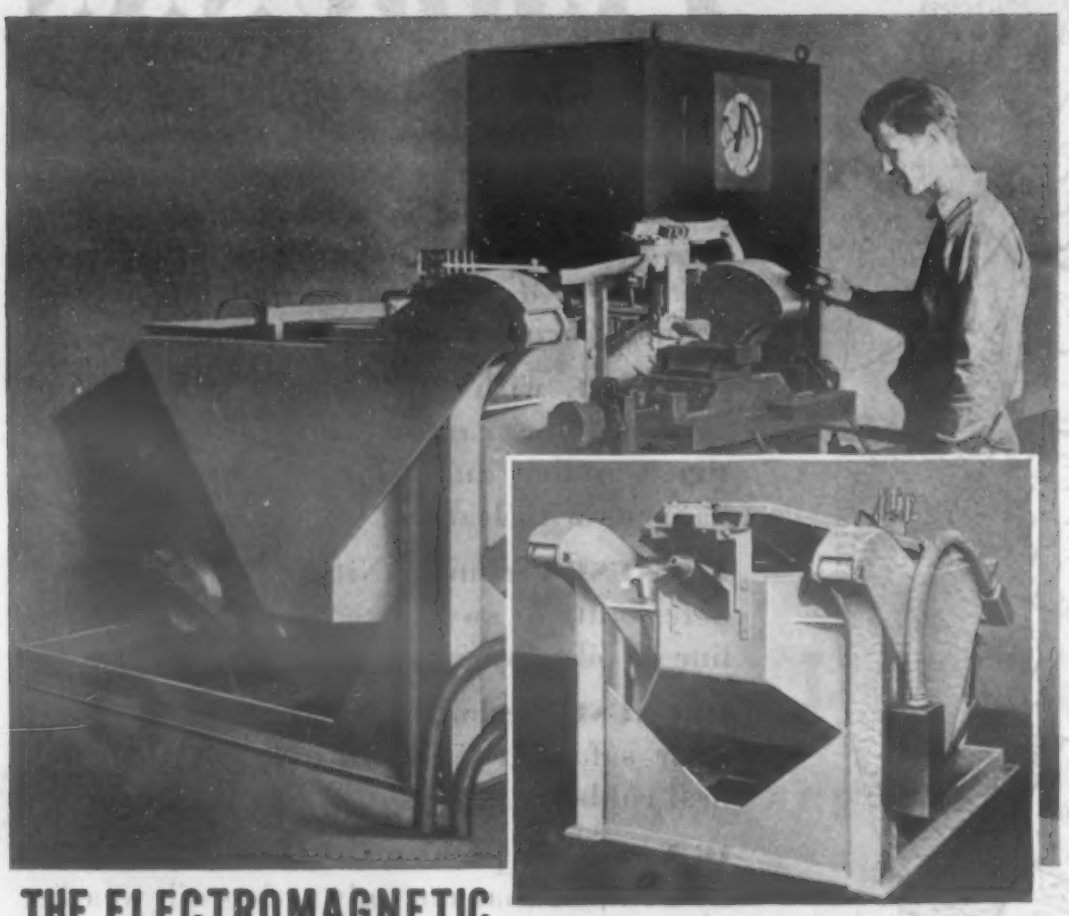
IF YOU have problems that could be solved by a rubber that not only resists oil, weather extremes, abrasions and wear . . . but also *holds* delicate colors—write our nearest office!

PERBUNAN
REG. U. S. PAT. OFF.

THE RUBBER THAT RESISTS OIL, COLD, HEAT AND TIME

ENJAY COMPANY, INC., 15 West 51st Street, New York 19, N. Y.; First National Tower, 106 South Main Street, Akron 8, Ohio; 221 North La Salle St., Chicago 1, Illinois; 378 Stuart Street, Boston, 17, Massachusetts. West Coast Representatives: H. M. Royal Inc., 4814 Loma Vista Avenue, Los Angeles 11, California. Warehouse stocks in Elizabeth, New Jersey; Los Angeles, California; Chicago, Illinois; Akron, Ohio; and Baton Rouge, La.

A *New* NON MECHANICAL METHOD FOR CONTROLLED PUMPING OF MOLTEN METAL

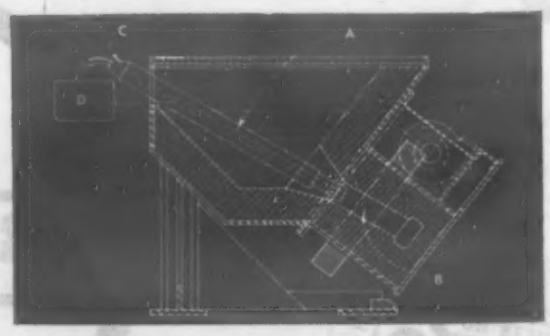


The large photo shows the Ajax-Tama Electromagnetic Pump at work. Control cubicle in rear maintains temperature, energizes pump from electric timer, electric eye, or similar devices. Second photo is a close-up of the pumping unit.

THE ELECTROMAGNETIC MOLTEN METAL PUMP* BY AJAX

Here is a device for the precise control of the flow of molten metals like aluminum, zinc or brass. It can be used to mechanize operations where today a hand ladle, a tapping spout, a tilting equipment or a siphon is used.

The electromagnetic pressure created by the high current in the loop of an Ajax Twin Coil Induction Unit is utilized to control and channel the metal stream in one direction; it lifts pure metal from the bottom of the hearth through an electrically heated refractory pipe over the metal level to its destination. The electric current alone controls the flow.



A cross section of unit showing discharge pipe (A), induction channel where pressure is created (B), pouring spout (C), and mold (D).

*Patents applied for and allowed.

Castings ranging from ¼ lb. to 30 lbs. or more can be poured in endless repetition with good accuracy in weight. Special problems requiring a continuous flow of hundreds of pounds per minute can be handled by the same unit. The electromagnetic pump is also a molten metal reservoir maintaining metal temperature accurately.

Ask AJAX for more information.

AJAX ENGINEERING CORPORATION, Trenton 7, New Jersey

AJAX TAMA-WYATT INDUCTION MELTING FURNACE

Associate Companies: AJAX METAL COMPANY, Non-Ferrous Ingot Metals and Alloys for Foundry Use
AJAX ELECTROTHERMIC CORP., Ajax-Northrup High Frequency Induction Furnaces
AJAX ELECTRIC CO., INC., The Ajax-Hultgren Electric Salt Bath Furnace
AJAX ELECTRIC FURNACE CORP., Ajax-Wyatt Induction Furnaces for Melting

Conductivity Measured with Temperature Compensation

For continuous recording or for automatic control systems where temperature variations of the electrolyte make conductivity measurement difficult, *Industrial Instruments, Inc.*, 17 Pollack Ave., Jersey City 5, N. J., has developed a combination of sturdy measuring and pre-filled reference conductivity cells which provide for automatic temperature compensation.

Of heavy walled Pyrex construction and completely protected by Type 316 stainless steel sheaths, these conductivity cells are designed for rough handling in industrial service. They are provided with standard pipe thread fittings for mounting in pipe lines or through tank walls. Operating conditions may include corrosive solutions, temperatures up to 150 F, and pressures up to 50 psi.

New Developments in Electrodes, Torches, Welders

The Westinghouse Electric Corp., P. O. Box 868, Pittsburgh 30, Pa., is making two new Flexarc electrodes for a.c. or d.c. welding of cast iron. Castingweld and Freemachineweld were developed to hold thermal stresses to a minimum and to prevent extreme hardness in the heat affected zone. The castingweld deposit is relatively hard and, therefore, not machinable. The expansion and contraction of Freemachineweld closely matches that of cast iron; and its deposit is soft and readily machinable.

The *Air Reduction Sales Co.*, 60 E. 42 St., New York, has announced a new oxyacetylene welding torch, the Airco 800. This torch has a capacity for operating single flame welding tips from No. 0 to 13, inclusive, as well as multiflame tips to No. 15. It is suitable for almost any welding job from the thinnest sheet metal up to 1½-in. thick plate.

The *Victor Equipment Co.*, 844-54 Folsom St., San Francisco, Calif., has marketed a light brazing and soldering torch, Model 3401. This torch can be used with any practical fuel gas such as acetylene, natural gas, city gas or liquified petroleum gas in combination with compressed air or oxygen. Jewelers, dental laboratory technicians and hobbyists can find many uses for this torch, which is engineered for small heating jobs.

The *Lincoln Electric Co.*, Cleveland 1, Ohio, announces a new low priced carbon arc torch for use with a.c. welding machines. A high temperature flame is produced between two copper coated electrodes clamped in aluminum alloy jaws. Both carbons are easily adjustable and geared to move together so that the angle of the carbons can be kept constant at all times. This torch can be used for all types of brazing and soldering work, general heating and hard surfacing of thin materials.

(Continued on page 138)

What they learned in a printing plant may be *your key* to savings!

SHOWN above is a bronze printing press roll. It is one of hundreds cast by the Shenango-Penn *centrifugal* process and then completely finished to specification in the modern Shenango-Penn shops.

Printing plants supplied with these rolls find them to be superior to ordinary rolls. The printers save time and money. The press manufacturers or equipment suppliers save plenty, too! Here's why . . .

The Shenango-Penn centrifugal process provides stronger, pressure-dense castings with finer-than-usual grain. So the rolls readily take an ideal mirror finish, last longer, are better able to resist breakage or distortion. Trouble is avoided. Maintenance and service time is reduced. Moreover, metal is saved. So is finishing time, because there's less machining to do! And finally, imperfections such as sand inclusions and blow holes simply don't exist! There are fewer wasteful rejects. The finished rolls do a better job! Longer!

However, Shenango-Penn experience and facilities aren't by any means limited to bronze rolls. Here, virtually *any* symmetrical part, tiny or huge, ferrous or nonferrous, can be cast centrifugally and furnished rough, semi- or finish-machined, as you wish—bushings, bearings, sleeves, liners, collars, rings, etc. If you use or need such parts, we believe we can show you some really worthwhile savings and advantages. Why not let us *prove* it?

SHENANGO-PENN MOLD COMPANY

1572 West Third St. Dover, Ohio

Executive Offices: Pittsburgh, Pa.

FREE BULLETINS

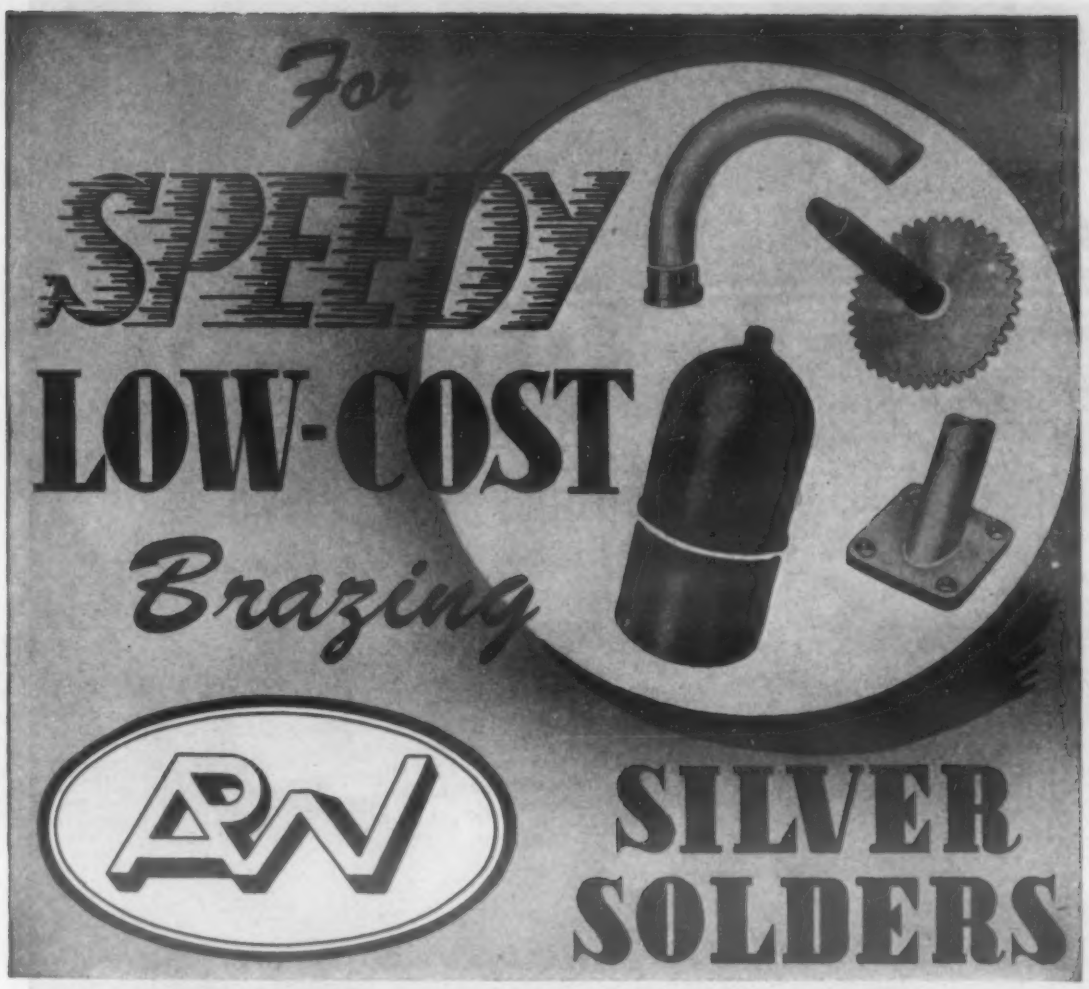
No. 143—Centrifugal castings of non-ferrous metals and alloys.

No. 144—Centrifugal and static castings of plain and alloyed irons.

No. 145—Centrifugally cast bushing stock in all standard sizes.

SHENANGO-PENN

ALL BRONZES • MONEL METAL • ALLOY IRONS



MANY FORMS FOR YOUR CONVENIENCE

We've had years of experience in developing and manufacturing low temperature brazing alloys to produce strong, sound joints on ferrous and non-ferrous metals.

Day in and day out the automotive, refrigeration, electrical and other industries are using APW silver brazing alloys...and getting good production records, too.

Don't wait for the next requisition . . . write now for our folder No. 45 and get acquainted with APW's wide range of brazing alloys.

Here are a few of our leaders that will interest you:

APW 217

Contains 45 per cent silver. Exceptionally fast flowing. Our leading alloy for large-scale production.

APW 205

Low in cost—high in strength—has 35 per cent silver content.

APW 355

A premium alloy for lowest temperature brazing—cadmium-free—highly ductile and corrosion resistant.

WE INVITE YOUR INQUIRIES FOR ANY QUANTITY...ANY SIZE

THE AMERICAN PLATINUM WORKS
Refiners and Manufacturers
PRECIOUS METALS SINCE 1875
231 NEW JERSEY R. R. AVENUE
NEWARK 5, N. J

The *Tri-Arc Corp.*, Chicago, Ill., has introduced a new high frequency unit that attaches to a.c. or d.c. welders. This unit provides an automatic arc that eliminates the "scratching" method. Because of the extra impulses it super-imposes, a more constant flow of current is obtained which makes easier welding and more positive control of the arc.

Banner Products Co., 4951 N. 29 St., Milwaukee, Wis., has designed and built a spot welder with a unique head construction. A steel guide through cylinder and piston wall prevents side play and assures clean uniform welds. Other features are: a rugged aluminum-bronze piston with long bearing surface; and three cast iron piston rings which reduce friction to a minimum.

Interchangeable Head Increases Flexibility of Polisher

A special abrasive belt head for automatic polishing and buffing is announced by the *Packer Machine Co.*, Meriden, Conn. The new interchangeable head permits various types of wheel applications as well as the use of abrasive belts.

Standardization of mounting design makes it adaptable to most types of Packer-Matics now in use. The ability of these machines to handle changes in product design without necessitating any change in equipment is thus greatly increased.

The flexibility of the new abrasive belt head permits single operating automatic

The interchangeable head on this machine permits the use of a variety of wheels and abrasive belts.

buffing and polishing of such items as door knobs, cooking utensils and die castings. The new head will accommodate the use of buffs, polishing, tampico and wire wheels or an abrasive belt.

Complete trolley for overhead conveyor. Each trolley consists of two wheels and two brackets. Both wheels and brackets are TOCCO-hardened. *(Photo courtesy Link Belt Co.)*

HARDENING COSTS CUT 75% with TOCCO* Induction Heating

● This TOCCO-hardened conveyor trolley bracket may be a long call from *your* product, but its case is typical of the savings accomplished by induction heating of metal parts of all sizes and shapes. Note these advantages:

1. CUTS COSTS—Hardening cost per bracket has been cut 75% by the adoption of induction hardening. Present cost is just one-fourth of cost when conventional hardening methods were employed.

2. STREAMLINES PRODUCTION—TOCCO eliminates carburizing, hauling and sandblasting—can be placed right in production line, next to related operations.

3. IMPROVES PRODUCT—TOCCO hardens wearing surface only—thus preserves original toughness and ductility of remainder of part.

TOCCO Engineers are glad to explore your operations for similar cost-cutting improvements—without obligation.

THE OHIO CRANKSHAFT COMPANY

TOCCO

*Trade Mark Reg. U.S. Pat. Off.

Mail Coupon Today

FREE BULLETIN

THE OHIO CRANKSHAFT CO.
Dept T-4, Cleveland 1, Ohio

Please send copy of "TOCCO Hardening".

Name_____

Position_____

Company_____

Address_____

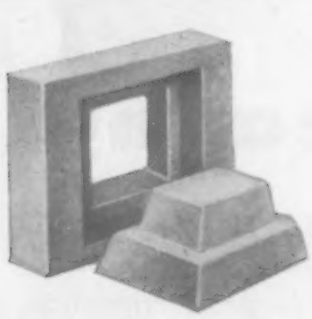
City_____ Zone___ State_____

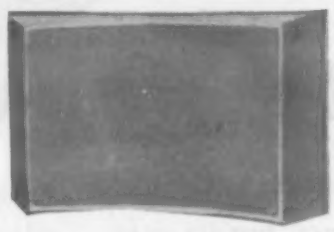
QUICKLY CAST! QUICKLY AVAILABLE!

J-M FIRECRETE* for casting special shapes

In less than 24 hours, your own special refractory shapes are ready—when you cast them with quick-hardening J-M Firecrete right in your own plant.

Firecrete mixes and pours as easily as concrete, hardens quickly with negligible spalling and shrinkage. Cast Firecrete in any shape you need—for furnace covers and bottoms, door linings, baffle tile, burner rings and other types of monolithic construction.





Firecrete is available in three types: STANDARD for temperatures up to 2400 F.; H.T. for temperatures up to 2800 F.; L.W. (light weight, low conductivity) for temperatures up to 2400 F.

J-M Firecrete is promptly delivered by your J-M Distributor

You can get quick delivery of Firecrete from your authorized J-M Refractory Distributor. There are more than 300 strategically located J-M Distributors who keep Firecrete in stock.

For further information about Firecrete, write for folder RC-17A, Box 290, New York 16, New York.

Reg. U.S. Pat. Off.

JOHNS-MANVILLE JM PRODUCTS

Johns-Manville FIRECRETE
The Standard in Castables

Liquid Adhesives Cement Metals, Wood, Plastics, Fabric

Two new modified phenolic liquid adhesives designed for cementing metals, thermosetting plastics, wood, fabric or any combination of these, have been developed by the *General Electric Co.'s Chemical Dept.*, Pittsfield, Mass.

Designated as G-E Adhesives Nos. 12507 and 12508, the new bonding agents, when properly cured, exhibit high shear and tensile strength and exceptional resistance to water, gasoline, kerosene and mineral oils. The adhesives are especially useful for cementing metals and laminates, for preparing metal faced, sandwich-type construction, for attaching brackets and lugs to thin metal sheets, and for the light vehicular construction found in trailer walls, airplane fuselage walls, and the walls of prefabricated housing. The use of these adhesives eliminates the necessity for sanding plastics.

Recommended for thermosetting plastics because of its superior flow characteristics, G-E Adhesive No. 12507 has exceptionally high solvent resistance. It is designed for applications which require an effective adhesive with a high shear strength where facilities are available for pre-baking the adhesive film before pressing.

G-E adhesive No. 12508 is recommended for applications in which the adhesive must possess exceptionally high cleavage strength and in which higher application pressures are available for assembly.

Production Line Heater Reduces Paint Viscosity

Heating paint to about 200 F just before it reaches a spray gun thins it out and makes it much easier to apply. *Bede Products, Inc.*, 3309 W. 118 St., Cleveland 11, Ohio, has perfected a new Trirex paint heater that can be put on the production line without causing maintenance headaches. The heater is installed between the pressure tank and the spray gun, and will heat the paint to any desired temperature between 60 and 200 F at the rate of 7 gal. per hr.

Thermal control at elevated temperatures reduces the need for thinners; it also enables the spray gun to work better because the paint particles are atomized more easily and thoroughly. Better atomization gives a smoother finish with less orange peel and less chance for sags. With certain types of finishes, a much higher gloss is obtained.

The Trirex heater is not limited just to paints. Lacquers, synthetics, wrinkles and baking enamels also can be applied with this unit.

★ You can
Reduce Costs
★ You can Improve
Performance with

ARNOLD

PERMANENT

MAGNETS

Where's the manufacturer these days who doesn't need all the competitive and cost advantages he can get? Maybe you have new electrical or mechanical equipment in mind—designs or re-designs that should employ permanent magnets for best results. Maybe you have existing applications that permanent magnets will do *better*—save you time and money in production, and step up the efficiency of your product.

In either case, let Arnold's engineering service help you to find the answers to your magnet problems. Arnold offers you a fully complete line of permanent magnet materials, produced under 100% quality-control in any size or shape you require, and supplied in any stage from rough shapes to finish-ground and tested units, ready for final assembly. Write direct, or to any Allegheny Ludlum branch office.

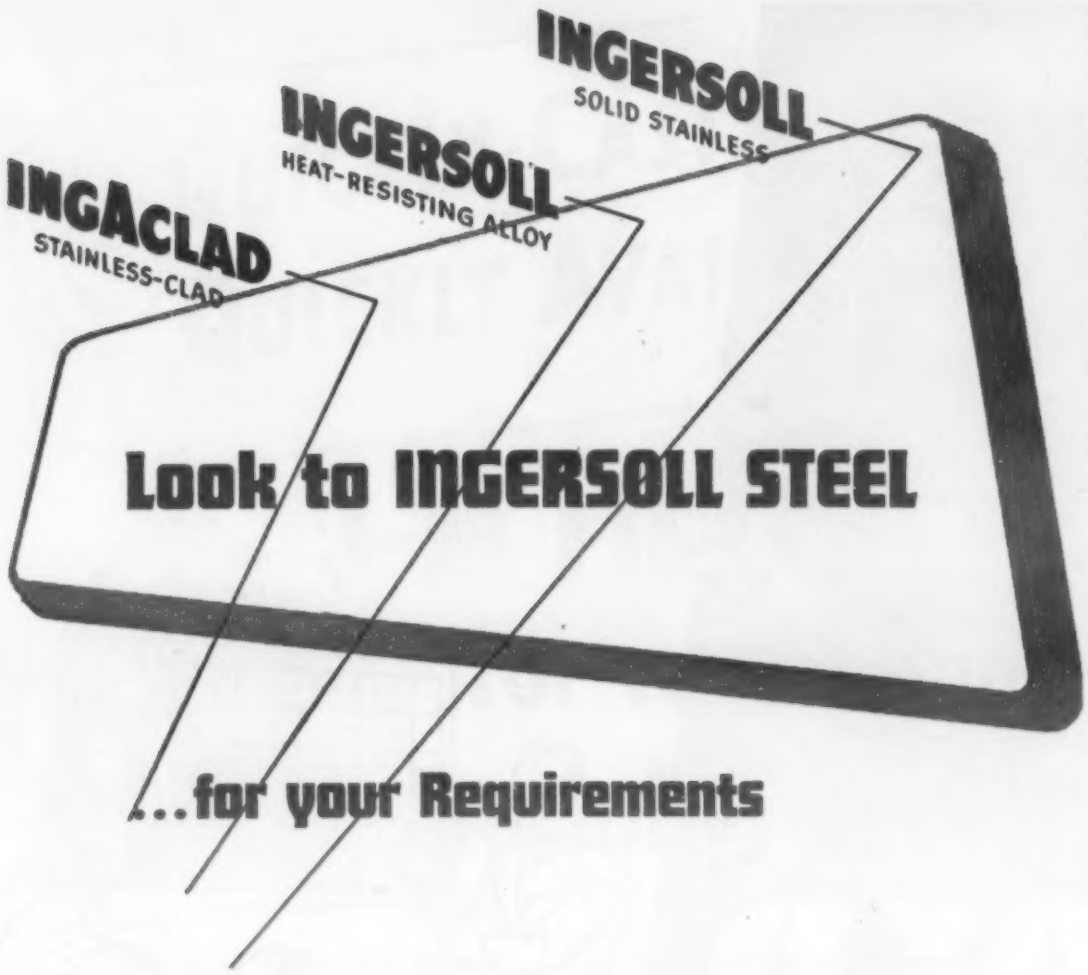
W&D 1295

THE ARNOLD ENGINEERING CO.

Subsidiary of ALLEGHENY LUDLUM STEEL CORPORATION

147 East Ontario Street, Chicago 11, Illinois

Specialists and Leaders in the Design, Engineering and Manufacture of PERMANENT MAGNETS



You've got a problem involving steel. You're planning a new product . . . modernizing your plant . . . designing new equipment. You may need solid stainless . . . maybe stainless only on the exposed or contact side . . . maybe a special heat-resisting alloy.

Remember, Ingersoll produces not only solid stainless—but heat-resisting alloys and IngAclad Stainless-Clad Steel as well.

Our recommendations are unbiased. Our advisory service is yours for the asking—without cost or obligation. Write, wire or phone.

ENGINEERING B-W PRODUCTION

INGERSOLL
STEEL DIVISION

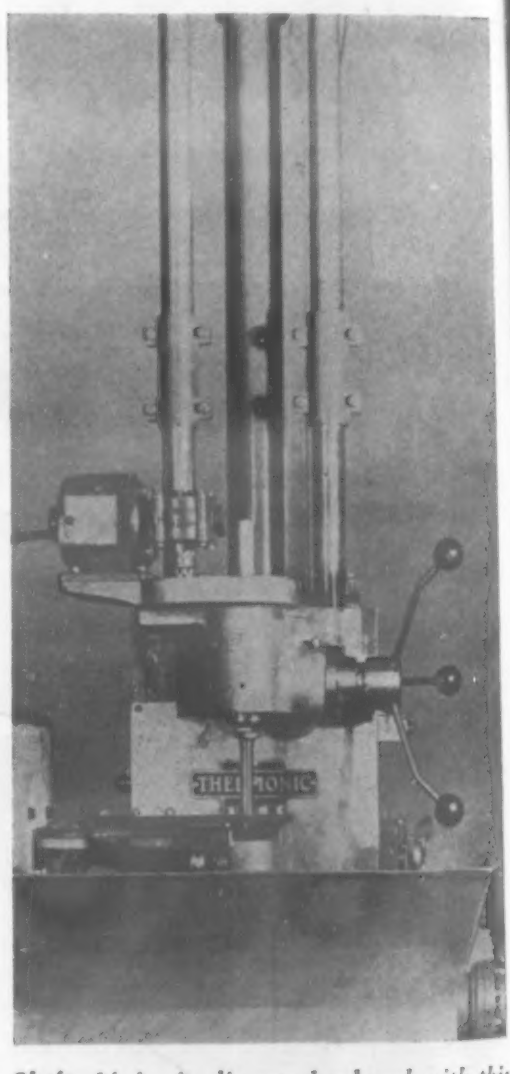
BORG-WARNER CORPORATION • 310 S. Michigan Ave., Chicago 4, Ill.
PLANTS: Chicago, Ill. • New Castle, Ind. • Kalamazoo, Mich.

Automatic Unit Induction Hardens Motor Shafts

Equipment consisting of one Model 1070 Ther-Monic Induction Heating Generator and one single position Ther-Monic Work Table with automatic progressive feed and spray quench is manufactured by the *Induction Heating Corp.*, Brooklyn, N. Y., for hardening motor shafts.

The heating operation and the rate of progression of the piece through the work coil are automatically controlled by a series of dogs which actuate the high frequency generator and a hydraulic valve. The dogs can be adjusted to accommodate either the drive shaft or the propeller shaft, or a wide range of similar parts. The vertical motion of the progressive feed is hydraulically powered by a self-contained pumping system.

The work is loaded with the fixture carriage in the up position. Upon being started, the carriage progresses the work downward through the inductor block and into spray quench. Rotation of the work is supplied during this operation by an electric motor and reduction gear mounted above the top of the spindle.



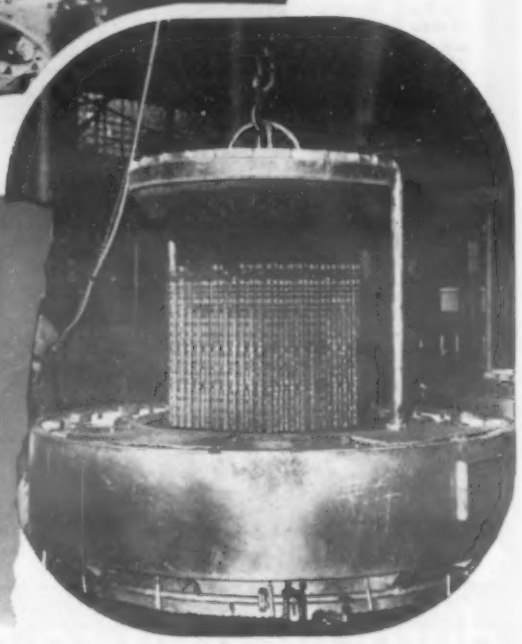
Shafts ½ in. in dia. are hardened with this unit to a depth of 0.040 in. in less than 11 sec. Resultant Rockwell C hardness is 50 to 53.

Upon completion of all hardening operations the fixture automatically returns, at an accelerated rate, to the up position for unloading and re-loading. The entire operation, between loading and unloading, is automatically controlled.

ANOTHER "SURFACE" PRODUCTION LINE INSTALLATION

* 256 CAMSHAFTS (per unit) GAS CARBURIZED

to produce a 0.080 hardenable case in this battery of 8 'Surface' Pit Type Furnaces



Top—*View showing 8 'Surface' Pit Type, Radiant Tube Heated Furnaces. Four cooling pits are shown in foreground. Note control panels at background of furnace.*

Bottom—*Charging a 'Surface' Pit Type Gas Carburizing Furnace. 256 camshafts are suspended from a special rack on underside of cover.*

PERFORMANCE DATA

Material: Camshafts
Process: Gas Carburize to 0.080 in case depth*
Cycle: Heat to 1700°F.— 5 hours
Hold at 1700°F.—10 hours
Cool to 1500°F.— 2 hours
Total 17 hours
Work transferred to cooling pits
Atmosphere: Purge and heat-up—RX Prepared Gas
Final heat and carburize—RX and Natural Gas
"Diffusion" or cool—RX Prepared Gas
No prepared atmosphere in cooling pits
*Hardenable case

● Eight 'Surface' Pit Type, Gas Carburizing Furnaces were selected for this leading automotive plant because the depth of case specified, which necessitates subjecting of the parts to the carburizing temperature from ten to twelve hours, would require a continuous furnace of a size that would be impractical for economical operation. However, "production line" methods were applied which outmoded former pack methods that were dirty and less flexible, and resulted in higher labor costs.

These gas carburizing furnaces have a capacity for 4350 pounds, or 256 camshafts each. The camshafts hang from the underside of the cover. Each furnace is heated by 16 vertical, gas fired radiant tubes.

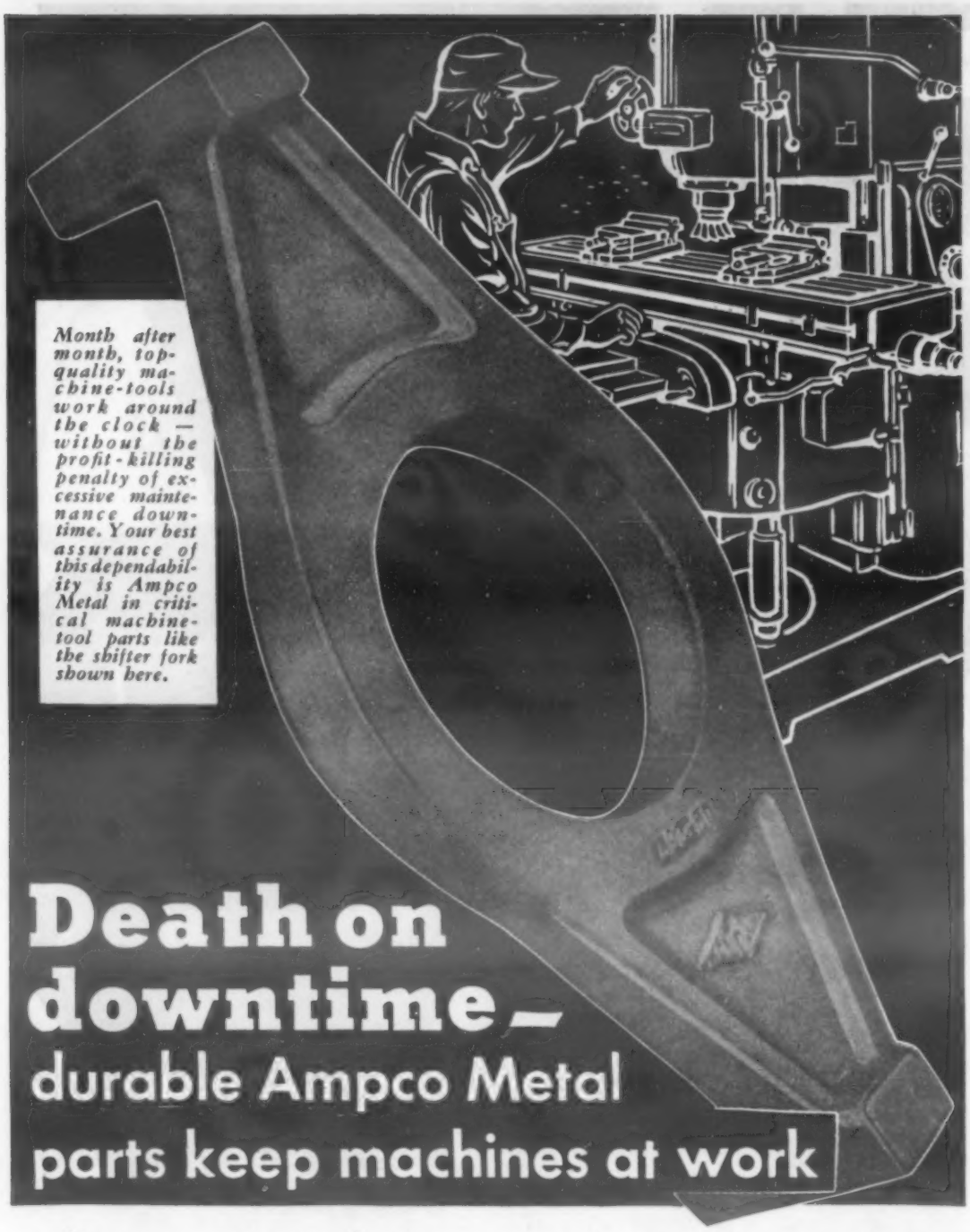
A dual gas system in which the carburizing gas is supplied for part of the cycle only, is used for the operation. 'Surface' RX Prepared Gas Atmosphere is used for the purge and heat-up operations; RX and natural gas are used for the final heat and carburization, and RX gas only for the "diffusion period."

The carburizing cycle plus the "diffusion period" during which the camshafts are reduced in temperature to 1500°F., provide an accurate control of the depth of the carbon case and the precentage of carbon on the surface of these parts. The complete heating, holding, and cooling cycle takes 17 hours.

If you would like complete data covering "Modern Gas Carburizing Processes and Equipment," including gas carburizing, suspended carburization, carbon restoration (skin recovery), and dry cyaniding, write for a copy of 'Surface' Bulletin SC-134. No obligation.

SURFACE COMBUSTION CORPORATION, TOLEDO 1, OHIO

'Surface' INDUSTRIAL FURNACES •



Month after month, top-quality machine-tools work around the clock — without the profit-killing penalty of excessive maintenance downtime. Your best assurance of this dependability is Ampco Metal in critical machine-tool parts like the shifter fork shown here.

Death on downtime— durable Ampco Metal parts keep machines at work

This wear-resistant aluminum bronze reduces maintenance time and replacement costs . . .

There's no ceiling on the cost of expensive downtime, but there's good insurance against it—durable Ampco Metal in critical machine-tool parts. The extra wear-resistance of this modern aluminum bronze means longer and better service—lower maintenance costs.

Ampco Metal parts are a mark of quality to look for when you buy new equipment. Replace worn parts in your present machines with Ampco Metal to reduce replacement frequency in the future and slash your service and maintenance costs to a new low.

Ampco Metal can be produced by centrifugal- and sand-casting, extrusion, or forging processes according to your requirements. Let your nearby Ampco engineer help you select the proper grade for your needs, from the seven standard grades and several modifications available. For complete information, write for Bulletin 71.

AD-32A

Ampco Metal has 7 outstanding performance advantages

Excellent bearing qualities • High strength-weight ratio • High compressive strength • High impact and fatigue values • Corrosion resistance • Wear resistance • Efficiency at extreme temperatures.

Ampco Metal, Inc.
Dept. MA-4, Milwaukee 4, Wis.
Field Offices in Principal Cities

AMPCO
TRADE MARK
REG. U. S. PAT. OFF.

Controlled Atmospheres Used in Gas-Fired Furnaces

Gas-fired furnaces for annealing, carburizing, drawing, hardening, spheroidizing, malleablizing, normalizing, and dry cyaniding are now available from *Westinghouse Electric Corp.*, East Pittsburgh, Pa. These units will supplement the regular line of Westinghouse electrically heated industrial furnaces and will be designed for use with separately prepared protective atmospheres such as Exogas, Endogas, Monogas or Ammogas.

The addition of gas-fired furnaces will also permit the inclusion of furnace equipment for such specific heat treating applications as gas carburizing and dry cyaniding. Among some of the gas-fired furnaces available are: cylindrical bell types used for bright annealing of copper wire in coils and in reels, of steel wire or strip, and other applications such as spheroidizing or drawing; continuous pusher types for annealing, gas carburizing, hardening, and malleablizing; continuous roller hearth furnaces for applications such as cycle annealing, hardening, malleablizing, and drawing; and continuous conveyor furnaces for heat treating applications where light and medium weight parts are involved.

End Mill Has Three Cutting Flutes

A new line of regular double end mills made with three cutting edges instead of the conventional 2- and 4-flute have been introduced by *Cadillac Cutter Co.*, 1613 Eastern S. E., Grand Rapids 7, Mich.

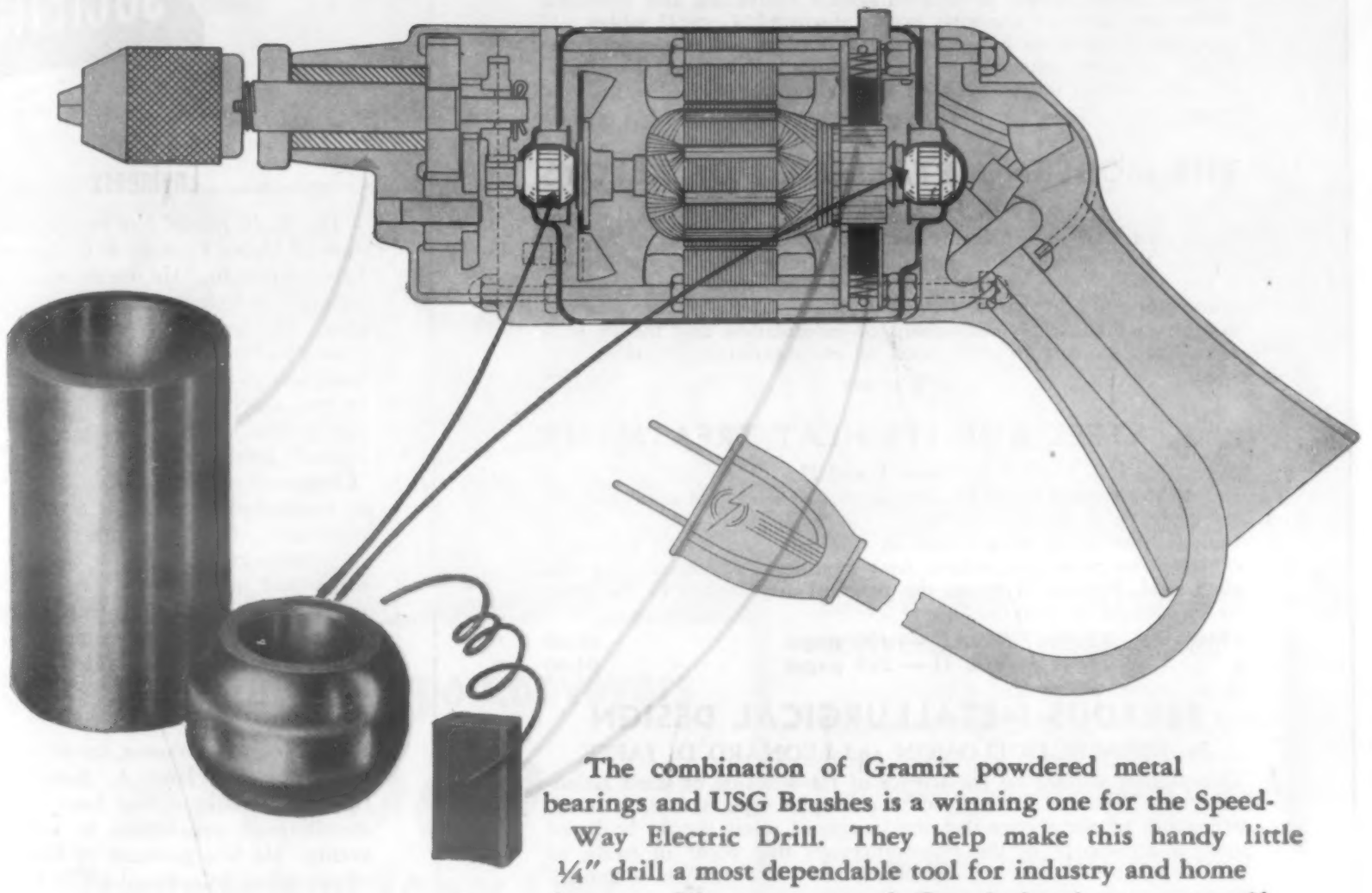
The 3-lip mill has many operational advantages. It will hog metal as fast as the 2-flute and leave the finish of the 4-flute. It cuts with a shearing action like the 4-flute but with no chatter or hammer. With the added chip room it will cut much faster and run cooler than the 4-flute. For die or mold work the operator can use one tool for both hogging and finishing.

This mill is made with heavier web construction than the conventional type end mill, giving it greater strength with less chance of breakage. The insides of the flutes are ground to a high finish. Hook rake angles are designed to give maximum shearing action. Clearance angles will give the greatest cutting efficiency in the toughest steels.

The tool is made without the common center hole in the end, which allows milling straight down in the work before starting the cut.

Perfect concentricity is guaranteed as all manufacturing operations are performed while the mill is held by its outer diameter, in the same manner as it is to be used in actual operation.

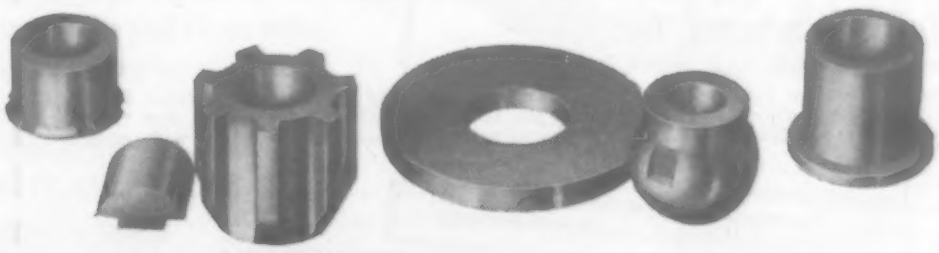
gramix bearings and USG brushes team up to provide top dependability for SpeedWay Drill



The combination of Gramix powdered metal bearings and USG Brushes is a winning one for the SpeedWay Electric Drill. They help make this handy little ¼" drill a most dependable tool for industry and home shop use. The strong, tough Gramix bearings — two self-aligning and one sleeve type — *keep shafts rotating free and true with a minimum of noise and wear.* Because they are porous, they retain lubricant and release it to the shaft as required. And because they are made by die-pressing powdered metals to exact size and with perfect bearing surfaces, they *do not require costly hand finishing or machining.* Hence, although they're more dependable, Gramix bearings cost less than conventional machined bearings. With USG Brushes also on the job, contributing their quiet, long-life performance, it's little wonder that this No. 69 drill is one of the most popular Blue Line tools produced by SpeedWay Manufacturing Co. of Cicero, Ill. Gramix bearings are not only used extensively in SpeedWay Blue Line Portable Electric Tools but also in its Silver Line Electric Motors.

We may be able to show you how Gramix powdered metal bearings, bushings, or other parts may *improve the performance of your product and save you money.* Send us prints for specific recommendations. Ask about our complete line of USG graphite, carbon-graphite, and metal-graphite brushes. **Write for your copy of the 264-page catalog of Gramix parts and specifications.**

gramix



THE UNITED STATES GRAPHITE COMPANY • SAGINAW, MICHIGAN

RECENT WILEY BOOKS

CORROSION HANDBOOK

Edited by HERBERT H. UHLIG

In this first authoritative book on metal corrosion, the author has correlated the work of 102 leading scientists and engineers covering every aspect of the subject. The basic theory, corrosion behavior of metals and alloys—aqueous and atmospheric as well as behavior at high temperatures, protection against corrosion, and corrosion testing are some of the vital points discussed. General tables and excellent illustrations help clarify the practical text. Corrosion rates under precisely defined exposure conditions have been listed and are expressed in units which are now virtually standard terms.

1948 **1192 pages** **$12.00**

THE MODERN METALLURGY OF ALLOYS

By R. H. HARRINGTON

Based on a series of articles by the author on "Metallurgy of Modern Alloys," this book is completely different from others on the subject. It emphasizes "why" rather than giving a statistical compilation on alloy properties. It has a system of modernized, definitive terminology, and a useful relationship of information and theory such as can be found in no other book on the metallurgy of alloys.

1948 **208 pages** **$3.50**

Bullens' STEEL AND ITS HEAT TREATMENT

Volumes I and II

Fifth Edition prepared by the Metallurgical Staff of Battelle Memorial Institute, directed by W. H. Gillett.

Contains the latest information in this important field. Volume I explains the principles behind heat treatment of both carbon and alloy steel. Volume II shows the practical applications of the principles covered in Volume I.

1948 **Vol. I — 489 pages** **$6.00**
Vol. II — 293 pages **$4.00**

FERROUS METALLURGICAL DESIGN

By JOHN H. HOLLOMON and LEONARD D. JAFFE

This pioneer volume on the science of the selection of steels rationalizes the choice of a metal for a particular type of use. It is an exposition of the theory that the design of steels should be based upon a knowledge of the transformations that occur in steels, of their mechanical behavior, and of heat flow during heat treatment.

1947 **356 pages** **$5.00**

PHOTOELASTICITY, VOLUME II

By MAX M. FROCHT

Deals with the advanced theories and techniques of photoelasticity. Part I answers the fundamental question regarding the influence of the physical constants of the material on the stress distribution. Part II covers methods of two-dimensional photoelasticity. Part III deals with three-dimensional photoelasticity.

1948 **506 pages** **$10.00**

NOMOGRAPHY

By ALEXANDER S. LEVENS

A much-needed and important study of the fundamentals of nomography and graphical methods. Includes nomographs which will be valuable to workers in many fields not only directly but as indicators of what can be done to eliminate tedious mathematical computations. Problems bear directly on industrial practice.

1948 **176 pages** **$3.00**

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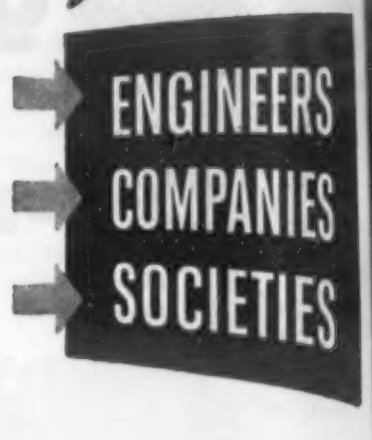
News of...



Engineers

Dr. *A. B. Kinzel* has been elected president of Union Carbide & Carbon Research Laboratories, Inc. He is a prominent author, lecturer and technical society committee man. His authorship involved papers on testing and welding of metals; on the metallurgy and physical chemistry of steelmaking; on the composition, physical properties and use of ferro-alloys and alloy steels, and on applied mechanics. He is co-author on "Chromium in the Alloys of Iron" series of monographs. He holds many patents in these fields. Dr. Kinzel was chief consultant in metallurgy to the Los Alamos Laboratories and the Argonne National Laboratories of the Atomic Energy Commission. He served on other war committees for the United States and her allies. Among his lectures was that before the Society of Culture of the U.S.S.R. in Moscow in 1936.

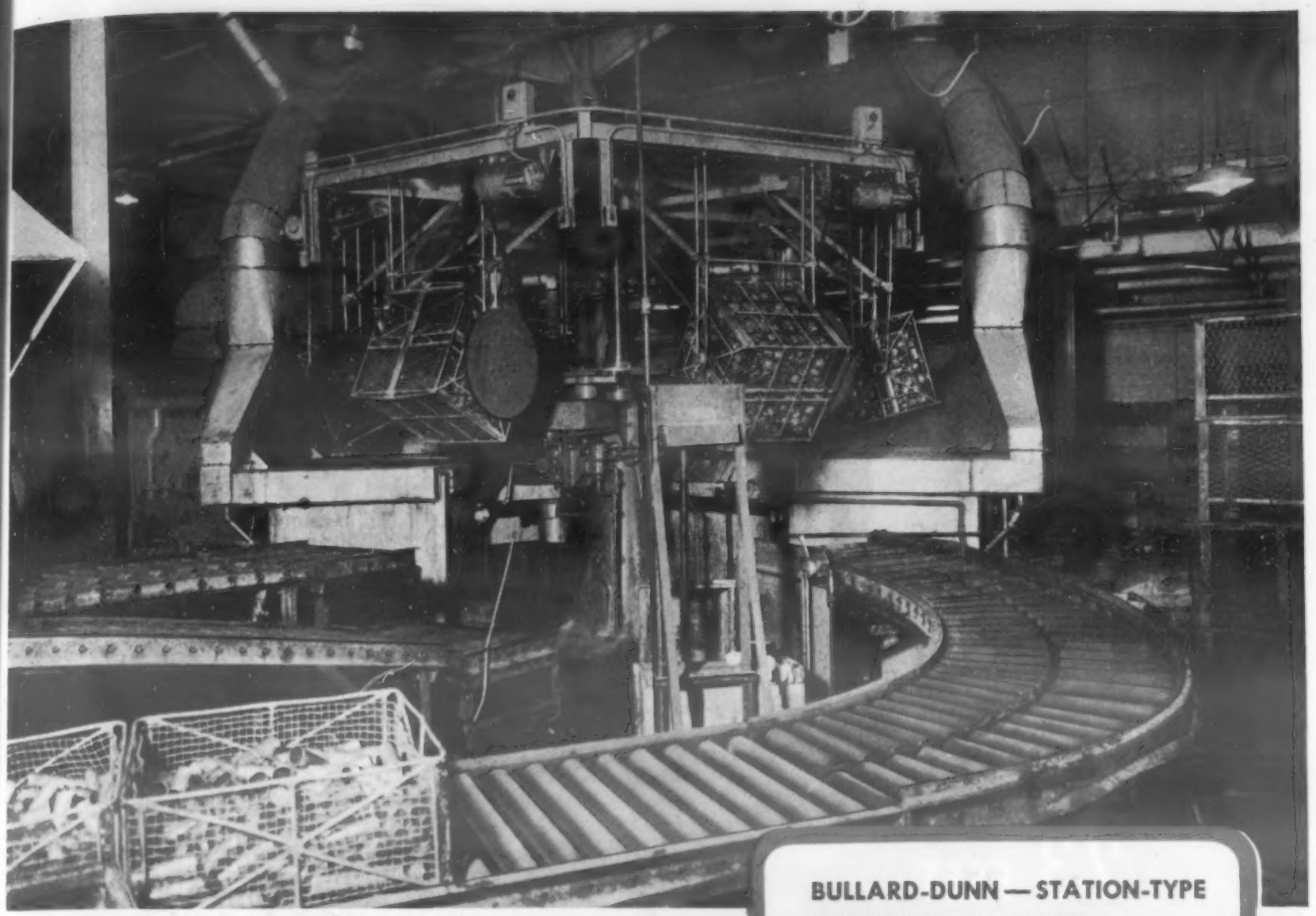
Dr. *Henry C. Boynton,* for 40 years metallurgist for the John A. Roebling's Sons Co., has been appointed head of the new metallurgical department at Temple University. He is a graduate of Harvard University where he received his Ph.D. in 1904. At that school he studied under Albert Sauveur. He has authored technical articles and is a charter member and past chairman of the Philadelphia chapter of the American Society for Metals.

E. Richard Walter, formerly chief metallurgist, Powdered Metal Products Corp., Franklin Park, Ill., has been made sales manager. He belongs to three technical societies.

George W. Strahan, formerly with International Nickel Co., and a member of the executive committee of the New York Chapter, American Society for Metals, has become sales manager for Westlectric Castings, Inc., Los Angeles.

Anthony J. Langhammer, president, Amplex Div., Chrysler Corp., Detroit, was the fourth recipient of the medal awarded annually by Stevens Institute of Technology for outstanding achievement in the field of powder metallurgy. In connection with the award, Mr. Langhammer gave a lecture on "Industrial Application of the Powder Metallurgy Process." The medal itself is made by the Stevens Powder Metallurgy Laboratory of silver powder pressed and sintered on the campus. The laboratory was established in 1939.

Theodore I. Leston has been made vice



Automatic Station-Type Conveyors

SPEED UP

Treatments at Lower Cost

Whatever your sequence of treatments, you can accurately time it and do better work at lower cost with a Bullard-Dunn Station-Type Conveyor, engineered to your specifications.

TESTED ON ALL KINDS OF WORK

During the past ten years, these fully automatic Bullard-Dunn conveyors with built-in hydraulic systems, have piled up great performance records on a wide variety of processes. Bullard-Dunn Process descaling is just one. Others include: pickling, bright dipping, plating, blackening, heat treating, hot tinning, rubber-mould cleaning, phosphate coating, treating aluminum and zinc.

WORK HOLDERS TO FIT THE JOB

Rotating barrels and cages for small parts and racks for large parts are available that can be used for both acid and alkali solutions and for high temperature salt bath treatments. Special work holders will be designed as required.

For details about Bullard-Dunn Station-Type Conveyors, write for Bulletin MM-BD-45. THE BULLARD COMPANY, Bullard-Dunn Process Division, Bridgeport 2, Conn.

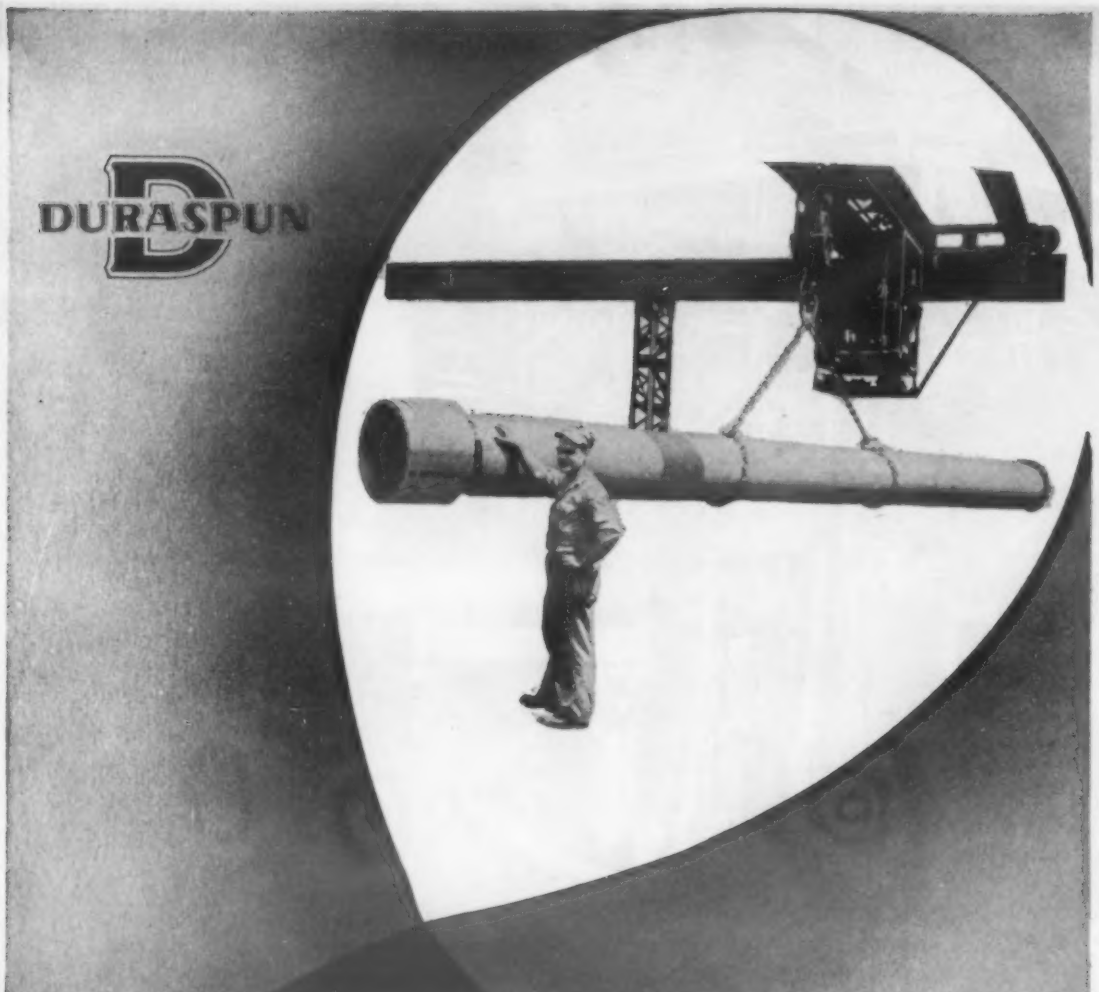
BULLARD-DUNN — STATION-TYPE CONVEYOR AT WORK . . .

. . . conveying annealed brass cups through 4-step pickling sequence between drawing operations at Bridgeport Brass Company, Bridgeport, Conn. *Operation:* baskets, arriving from furnace on roller conveyors, are loaded into specially designed, stainless steel cages, permanently fixed to machine . . . two baskets per cage. Cages rotate throughout accurately timed sequence in solution and while machine is automatically rising, indexing, and lowering. *Production:* Faster, better, more economical than previous hoist-operated unit. *Maintenance:* Machine has been operating for over one year without shutdown for major repairs.

BULLARD

Bullard-Dunn Descales Without Dimensional Change

The Bullard-Dunn Process removes scale and oxide from ferrous metallic surfaces without attacking the work. Fast . . . thorough . . . economical . . . simple to operate. Investigate. Bulletin MM-BD-46 tells story.



It's alloyed to meet a highly corrosive condition. It's centrifugally cast to give it the higher strength and greater metal density to meet a tough structural requirement. It's typical of what we can do in our centrifugal casting department. In this case two sections were made and welded together.

May we suggest that if you have need for any high alloy pipe or tube ranging in diameter from 2½ inches to 24 inches and, depending on diameter, up to 15 feet in length, you look into our centrifugal casting service.

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News of...

ENGINEERS COMPANIES SOCIETIES

president in charge of production, Eutectic Welding Alloys Corp., New York 13. A graduate in chemical engineering, he completed his metallurgical training at Faculte des Sciences, Paris, and New York University. At the former he worked under Madam M. Curie, covering preliminary phases of atomic research. He was assigned to Eutectic Welding's projects in the research laboratories in 1944, guiding several new arc welding electrodes and alloys through pilot plant stages to full production, becoming director of production in 1947.

Marvin J. Udy has opened an office at 564 Portage Road, Niagara Falls, N. Y., as consulting engineer in process metallurgy and in production of ferro-alloys, phosphorus and calcium carbide and in general electric furnace smelting.

Albert J. Fischer heads the product research and development laboratory of Adamas Carbide Corp., 40-30 Twenty-third St., Long Island City. A graduate engineer, he has enjoyed 14 years experience in tungsten carbide powder metallurgy. He was formerly with the carbide division, Firth Sterling Steel & Carbide Corp.

Russell Franks has been named chief metallurgist, with headquarters in Pittsburgh, of the technical service and development department, Electro Metallurgical Co. Mr. Franks is perhaps best known for his work with high temperature alloys during the war.

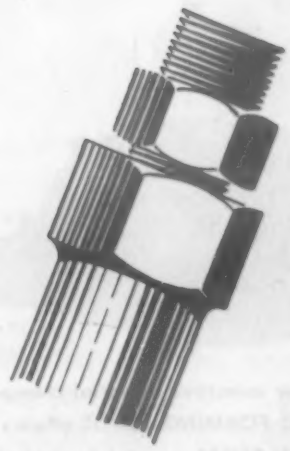
Dr. *Robert F. Mehl*, director, Metals Research Laboratory, and head, Department of Metallurgical Engineering, Carnegie Institute of Technology, has been appointed to the committee for the distribution of radioisotopes, according to the Atomic Energy Commission, Washington. He will be concerned with the distribution of isotopes for metallurgical research and industrial application.

Joseph R. Lex has been made assistant general manager, Progressive Welder Co., Detroit. A graduate of the University of Munich, Germany, Mr. Lex joined Progressive early in 1946, after having been plant manager, Fisher Body Welding Div.; general manager of a Detroit aircraft parts manufacturing firm; and consulting engineer on production processes and equipment, particularly in the resistance welding field.

R. J. Bryan has become plant manager of the Buffalo foundry of the Allegheny Ludlum Steel Corp. Dr. *P. K. Koh* has been made associate director of research in charge of tool and die steel and allied products, while *George I. Bottcher* has been made assistant chief engineer. Mr. Bryan has been in the foundry industry for 33 years, having been with some of the country's leading foundries. Dr. Koh was engaged in metallurgical research with Stand-

EXPERIENCED MACHINISTS INSIST..

Brass Valves Possess Great Machinability!



The free cutting characteristics of Brass are ideal in the manufacturing of all types of valves and other castings that require machining.

This outstanding quality of a Brass Casting . . . . . MACHINABILITY . . . makes it an efficient and economical friend of the machinist.

Specify- **LAVIN NON-FERROUS INGOT** *-Quality*

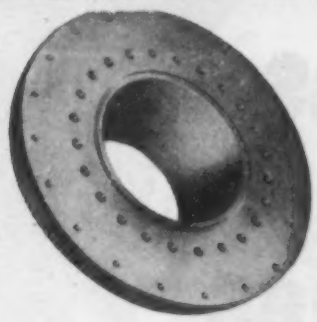
R. LAVIN & SONS, INC.

Refiners of Brass, Bronze and Aluminum

3426 SOUTH KEDZIE AVENUE · CHICAGO 23, ILLINOIS

REPRESENTATIVES IN PRINCIPAL CITIES

LENAPE MANWAY NECKS FOR HOODED CHLORINE TANKS



Typical of the versatility of Lenape Press Forged products is this 18" manway of silicon killed steel with specjal 37" O.D. flange. In addition to standard bolting, an outer circle of holes has been tapped to attach the hood or dome.

Lenape seamless necks, nozzles, and other pressure vessel fittings are produced in a complete range of sizes to code or private specifications in carbon steel, alloy steels, stainless, and other alloys.

Send blue prints and/or specifications for recommendation and prices. Our engineering department will be glad to discuss particular problems without obligation.

Quotations will be given our immediate attention — Bulletin 4-61 and current price schedule M-47 will be sent upon request.

LENAPE HYDRAULIC PRESSING AND FORGING CO.

LENAPE HYDRAULIC PRESSING & FORGING CO
DEPT. 102 WEST CHESTER, PA.

RED MAN PRODUCTS

from FLAT SURFACES TO INTRICATE SHAPES with the New DI-ACRO BRAKE

- ROK-LOK—new sensitive material clamp increases accuracy
- DOUBLE-EDGED FORMING BLADE allows close reverse bends
- NEW PRECISION STOPS accurately control angularity of bends

This versatile metal forming machine was developed for use in model shops, experimental laboratories and production departments where it often replaces dies for all types of precision forming operations. Di-Acro Brakes will form a great variety of materials including bronze, stainless steel, aluminum and bi-metals.

WRITE FOR CATALOG. New edition of 40-page Di-Acro Catalog contains detailed information on all Di-Acro Brakes, Shears, and Benders and illustrates how these precision machines can be used individually or cooperatively for "DIE-LESS DUPLICATING".

◀ DI-ACRO is Pronounced "Dio-Ack-Ro"

DI-ACRO PRECISION MACHINES DIE-LESS DUPLICATING

O'NEIL-IRWIN MFG. CO.

382 8TH AVE., LAKE CITY, MINNESOTA

News of...

ENGINEERS COMPANIES SOCIETIES

ard Oil Co. of Indiana before joining Allegheny Ludlum.

Charles Lukens Huston, Jr., lineal descendent of Isaac Pennock, founder of Lukens Steel Co., has been elected a vice president of that company. He will continue as executive assistant to the president. After graduating from Princeton in 1928 he was with the American Rolling Mill Co. for 10 years. He joined Lukens in 1939 and specialized in the designing, engineering and fabricating of steel plate structures by welding.

William B. Renois, once analytical chemist with Aluminum Co. of America and Monsanto Chemical Co., has been made general manager of sales, Gerrard Steel Strapping Co., U. S. Steel Corp. subsidiary.

Ralph R. Cooper has been appointed chief engineer, Patterson Foundry & Machine Co., East Liverpool, Ohio. He had previously been connected with rubber manufacturers and has had broad experience in machine design.

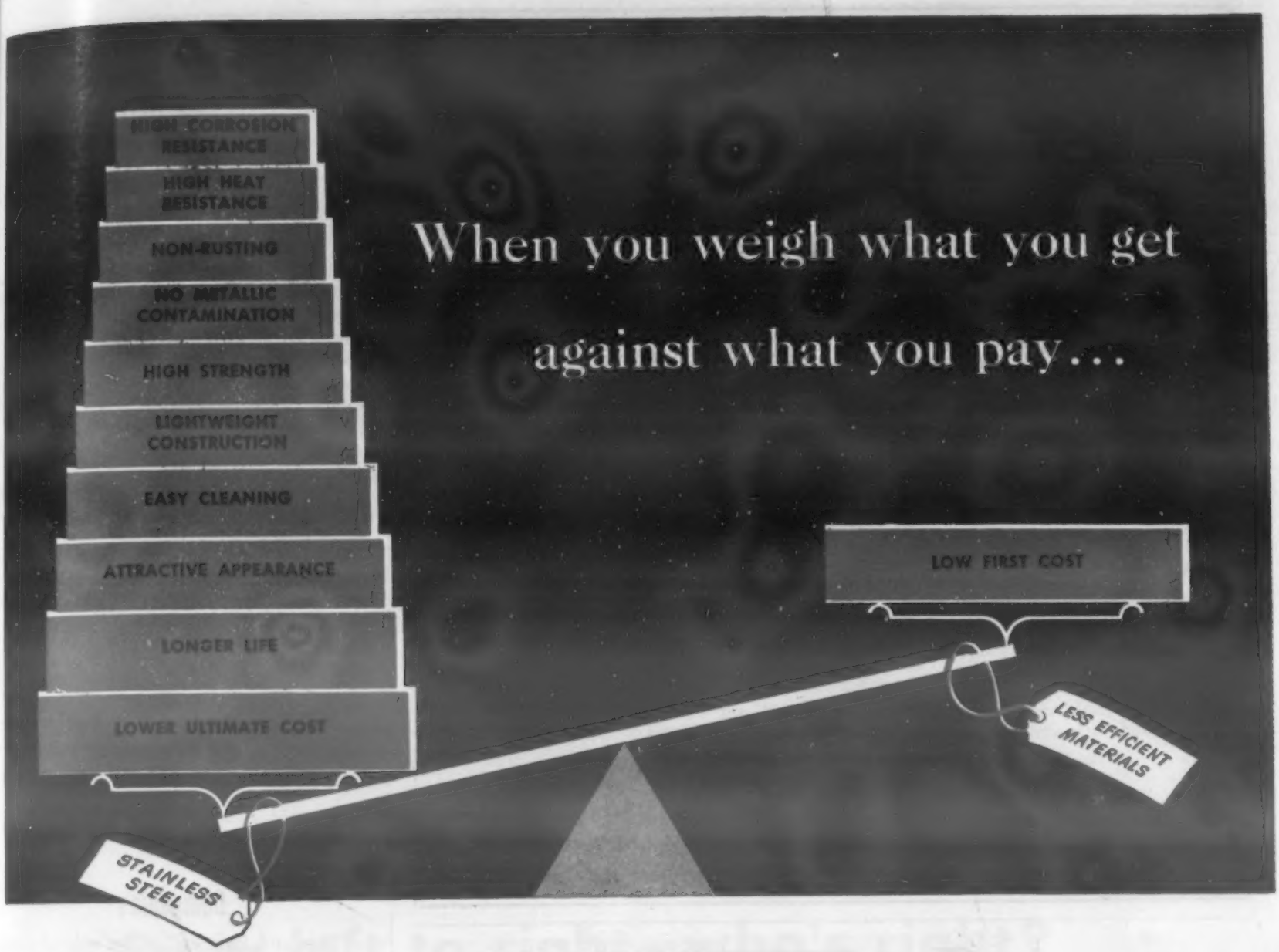
Edward B. Nitchie has become manager of operations and engineering of Basic Refractories, Inc., Cleveland. A graduate of Yale Sheffield Scientific School, he has enjoyed extensive experience in the chemical and engineering field.

Blair Glenn, general superintendent, Canton Bearing Div., Timken Roller Bearing Co., has been promoted to assistant factory manager, that division. *Henry Tobey,* Canton Bearing factory metallurgist, succeeds Mr. Glenn and is succeeded in turn by *Fred Barnard,* assistant Canton Bearing factory metallurgist, being followed, in line, by *Joseph Selby. Russell P. Fowler,* assistant general superintendent of the Columbus plant, has been made superintendent of the Bucyrus bearing factory.

Maurice J. Hoke has been made works manager, crankshaft and camshaft divisions, Ohio Crankshaft Co., having joined the company in 1945. The next year he became chief engineer. Previous connections had been with the Electromotive Div., General Motors Corp. and Consolidated Aircraft Corp. *Alfred H. Schott* has been promoted to master mechanic, having joined the company in 1941 from the Hickok Instrument Co.

Ralph L. Wilcox has been made vice president in charge of industrial sales and engineering at the Gerity-Michigan Corp., being a metallurgical engineer and authority on all phases of die casting. He served as consultant to the War Production Board. For 16 years he was a technical representative of the New Jersey Zinc Co. *W. Waite Broughton* succeeds Mr. Wilcox as Detroit divisional manager. During the war he was in charge of alloying at National Lead's magnesium plant at Luckey, Ohio, and was also at one time with New Jersey Zinc Co.

Merle J. Graham has become manager of



the balance is in favor of STAINLESS

MATERIALS less efficient than Stainless Steel have in their favor only one advantage—lower first cost. Against this Stainless offers ten advantages.

That's why Stainless Steel does so much more, does it so much better and lasts so much longer. That is why so often Stainless is by far the cheapest material you can use.

The time-wasting shutdowns it avoids where ordinary materials fail under corrosive attack or high heat —the weight Stainless Steel saves in equipment that must move or be moved—the lower cleaning costs its use ensures—the way it eliminates product losses caused by metallic contamination — the longer service life, fewer repairs and minimum maintenance that result from Stainless Steel's superior physical properties—all these far outweigh its sometimes higher cost.

These proved, money-saving advantages of Stainless you can obtain at their fullest in U·S·S Stainless Steel.

In U·S·S Stainless Steel we can offer you — *for almost immediate delivery*—a complete family of perfected, service-tested corrosion- and heat-resisting steels in a wide variety of forms, sizes and analyses. Plan to use them to improve your product or equipment. Our engineers who are specialists in the use of Stainless Steel will gladly recommend what grade to use and show you the best way to obtain optimum benefits at minimum cost. Ask for their assistance at any time.

U·S·S STAINLESS STEEL

USS STAINLESS STEEL — UNITED STATES STEEL

SHEETS · STRIP · PLATES · BARS · BILLETS · PIPE · TUBES · WIRE · SPECIAL SECTIONS

S-512

UNITED STATES STEEL AMERICAN STEEL & WIRE COMPANY, Cleveland, Chicago & New York
CARNEGIE-ILLINOIS STEEL CORPORATION, Pittsburgh & Chicago • COLUMBIA STEEL COMPANY, San Francisco
NATIONAL TUBE COMPANY, Pittsburgh • TENNESSEE COAL, IRON & RAILROAD COMPANY, Birmingham
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REQUIRE A VACUUM TIGHT JOINT BETWEEN GLASS AND METAL TUBING?

Cerroseal-35 will do the job quickly and permit taking apart easily.

The procedure: tin inside of metal tubing to depth of joint, using any flux. Wash off all flux. Tin outside of glass tubing by wiping molten alloy on tubing, which has been warmed to alloy's melting point, about 244° F. Warm both parts to be joined to give an appearance of wetness and insert glass tube into metal tube. Flow excess alloy into joint to completely fill space and allow to cool. Recommended alloy film thickness—.002" to .004".

Cerroseal-35 is one of a series of interesting and useful Indium alloys having very low melting temperatures.

They are:	Melting Temperature
Cerrolow-105	*105°F
" -117	117°F
" -136	136°F
" -147	*147°F
" -174	174°F
Cerroseal- 35	*244°F
" - 25	*294°F

*Non-eutectic alloys—yield temperatures are those given.

Suggested and actual uses: Fusible links in automatic fire alarm and extinguisher devices; in manual reset thermal switches for controlling processing; or for signalling rise of temperature, as in bearings; thermal safety controls in refrigeration, diathermy and electronic equipment. As a proof casting medium for delicate machine work, Cerrolow-117 can be poured without fear of over expanding metal parts and shrinks but .0002" per inch after casting.

Delicate soldering in small instruments will not be disturbed if dial covers are sealed with one of these low temperature melting alloys.

Describe your problem. Perhaps we can help.

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Materials for the Metallurgy of Tomorrow

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News of...

ENGINEERS COMPANIES SOCIETIES

the West Leechburg, Pa., plant of Allegheny Ludlum Steel Corp., having joined the company in 1933 and holding responsible positions in the production department. *Frank G. Benford* has been appointed assistant plant manager. For eleven years he was a metallurgist for General Electric Co., joining Allegheny Ludlum as chief metallurgist of the West Leechburg plant in 1945.

Ernest E. Brayshaw, a steel production engineer widely known in eastern steel circles, has been named works manager, Southwest Steel Rolling Mills, Los Angeles, having formerly been with Carnegie-Illinois and Bethlehem Steel companies. *H. F. Hazel,* with 40 years experience in West Coast steel mills, has been made superintendent. *James E. Pollak* is the new manager of construction materials, having formerly been executive with the Pollak Steel Co., Cincinnati, which was founded by his grandfather in 1865.

Companies

"Pigs and Progress" is the title of a new industrial moving picture, being the first in color to show the production of aluminum from raw bauxite to finished products. It is a 16-mm. sound and full color film, released by the *Reynolds Metals Co.*, Louisville 1, Ky. It is an attempt to carry non-technical persons behind the scenes and give them, in simple language, an insight into the transfer of bauxite into metallic aluminum. A particularly interesting scene is aluminum foil rolling from the mills.

Rigid-Tex Corp., Buffalo, producer of ferrous and nonferrous sheet and strip by a patented design strengthening process of rolling, plans to increase plant capacity by 30% after experiencing a 1947 sales volume double that of the preceding year. During the war the company produced special metals for the famous proximity fuse that proved so deadly.

Van Doren, Nowland & Schladermundt, industrial designers of New York and Philadelphia, have affiliated with two leading design firms in London and Paris which may result in the opening of new international markets for American materials and machinery abroad. The companies are European Field Research & Design Unit of London and Compagnie Pour l'Etude d'Equipments Industriels of Paris.

Revere Copper & Brass, Inc. is expanding production facilities on the Pacific Coast. It has begun erection of a plant for the manufacture of seamless copper and alloy tubing and brass rod at Los Angeles and is acquiring a plant at Riverside, Calif., to

(Continued on page 156)

From left to right—who's right?

"We CAN convert to aluminum! It's adaptable to almost any product!" He's right! There's an alloy of Kaiser Aluminum for almost every type of manufacturing operation. Kaiser Aluminum can be formed, drawn, spun, brazed, welded, joined. It can be painted or polished, or finished in almost any way.

"Our competitors are converting and are taking our customers!" He's right! Makers of everything from general appliances to garage doors, from toys to trailers, have converted to Kaiser Aluminum, are finding their products *more saleable!* Today, more than 1,000 manufacturers are making hundreds of different products out of Kaiser Aluminum.

"But aluminum costs too much!" He's *wrong!* Aluminum is now at *the lowest price in history!* Figure aluminum on a *unit cost basis*—not per pound—and you'll find that it compares favorably with any other metal or material. Besides, delivered price includes freight charges, and substantial savings are made on handling, finishing, shipping.

"We can be sure of a steady, long-term supply!" He's right! Permanente Metals, in less than two years, has added millions of pounds to the nation's annual aluminum production. And, you can be certain of *on-time* deliveries. Call any of our offices and an experienced sales engineer will demonstrate how *you* can convert to Kaiser Aluminum!

Kaiser Aluminum a Permanente Metals product

SOLD BY PERMANENTE PRODUCTS COMPANY, KAISER BUILDING, OAKLAND 12, CALIFORNIA . . . WITH OFFICES IN:
Atlanta • Boston • Buffalo • Chicago • Cincinnati • Cleveland • Dallas • Detroit • Kansas City • Los Angeles • Milwaukee
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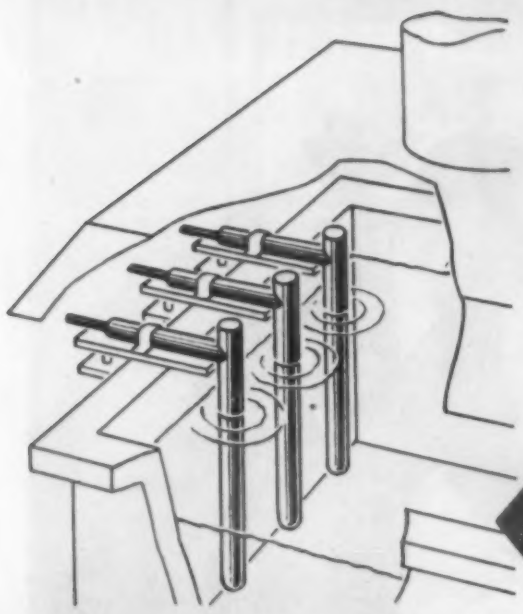

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IMMERSION HEATERS

has been developed by Amersil* —primarily for heating and pickling solutions for stainless or alloy steels, which:

Eliminates lead wire corrosion by bringing the leads through a fused silica sidearm.

Provides unusual compactness.
Insures high heat efficiency.
Offers a minimum of obstruction.
Can be installed quickly, easily.

Write Amersil, Department "M" for more complete details or ask for latest printed matter.

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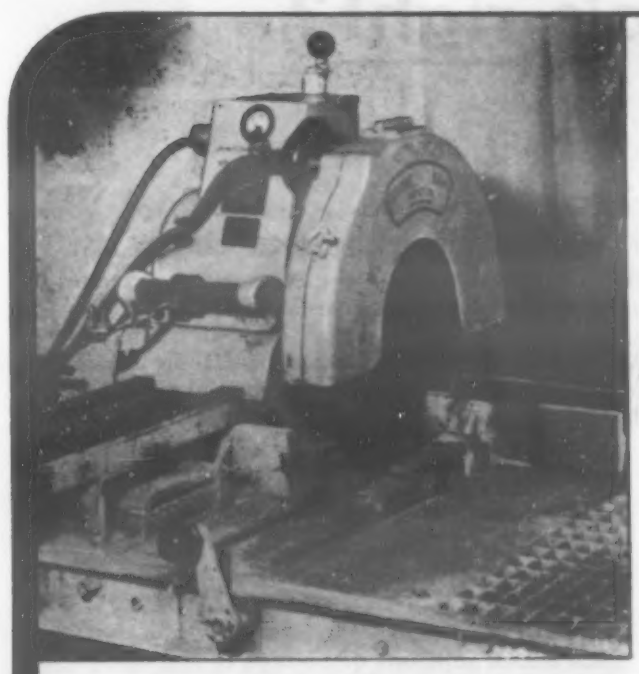

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WITH MILL-LIKE FINISH WITHIN TOLERANCES OF .008

Cut 8" Channel in 16 seconds
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Cut 1" Stainless Steel 1ft./min.

Better, faster and cheaper, cutting of . . . Structural Steel, Armor-plate, Stainless Steel, Pipe, Aluminum, Brass, Bronze, Copper, High Carbon, Ferrous and non-ferrous metals.

Write us today for further information.

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HIGH SPEED CUTTING MACHINERY
Dept. MM2 — Box 1363 — Syracuse, N. Y.

News of...

ENGINEERS COMPANIES SOCIETIES

manufacture copper clad stainless steel cooking utensils.

The Small Lot Stamping Co. has been established at 1025 W. Blancke St., Linden, N. J., to produce custom-made stampings from steel and nonferrous metals in small lots. The management has 17 years experience in this line and recently developed a new improved temporary tool which has increased speed, retaining accuracy. The new tool is made at one-tenth the normal cost and is good for runs of 10 to 50,000 pieces. Changes in design can often be made at $1 to $2.

Shareholders of the *American Rolling Mill Co.* will consider the proposal to change the name of their company to Armco Steel Corp. at their April 15 meeting. The name, "Armco," has been a trade mark for 34 years and is probably better known than the company's present official name, the sponsors of the change suggest.

Low cost market tests of new plastic products and simplified product development are the objectives of a new service announced by Fred J. Kirk, president, *F. J. Kirk Molding Co.*, 104 Brook St., Clinton, Mass. He offers custom injection molding of sample lots (100 to 5000 pieces) in the Short Run Shop. The specimens are used to make any kind of mechanical or chemical test.

The *Kaiser-Frazer Corp.* has bought a blast furnace and coke ovens in Utah from the War Assets Administration for $1,150,000. The blast furnace capacity is 300,000 tons yearly, while the 500 bee hive coke ovens turn out 750 tons daily. The purchase will aid the program of stepping up production of automobiles to 1500 daily. The plants originally cost $13,000,000.

The *Acheson Colloids Corp.*, Port Huron, Mich., maker of colloidal graphite products, has purchased its British counterpart, E. G. Acheson, Ltd., which, in spite of similarity of name, was a completely independent concern.

Eutectic Welding Alloys Corp., 40 Worth St., New York, which has previously sold its products directly, now offers to outstanding distributors the opportunity to handle its line.

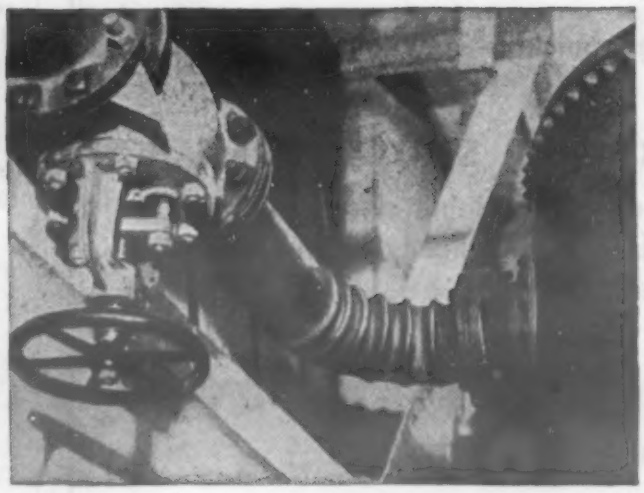
The *Union Mfg. Co.*, New Britain, Conn., has acquired the air chuck and air chuck cylinder business from the Hannifin Corp., Chicago.

The *Lustron Corp.*, Columbus, has placed additional orders of $2,079,617 in plant equipment for the making of porcelain enamel steel houses. Among equipment ordered are huge presses, special furnaces and cleaning, spraying and baking systems.

Two Hartford, Conn. industries have consolidated: The *Whitney Chain & Mfg. Co.* and the *Hanson-Whitney Machine Co.*,

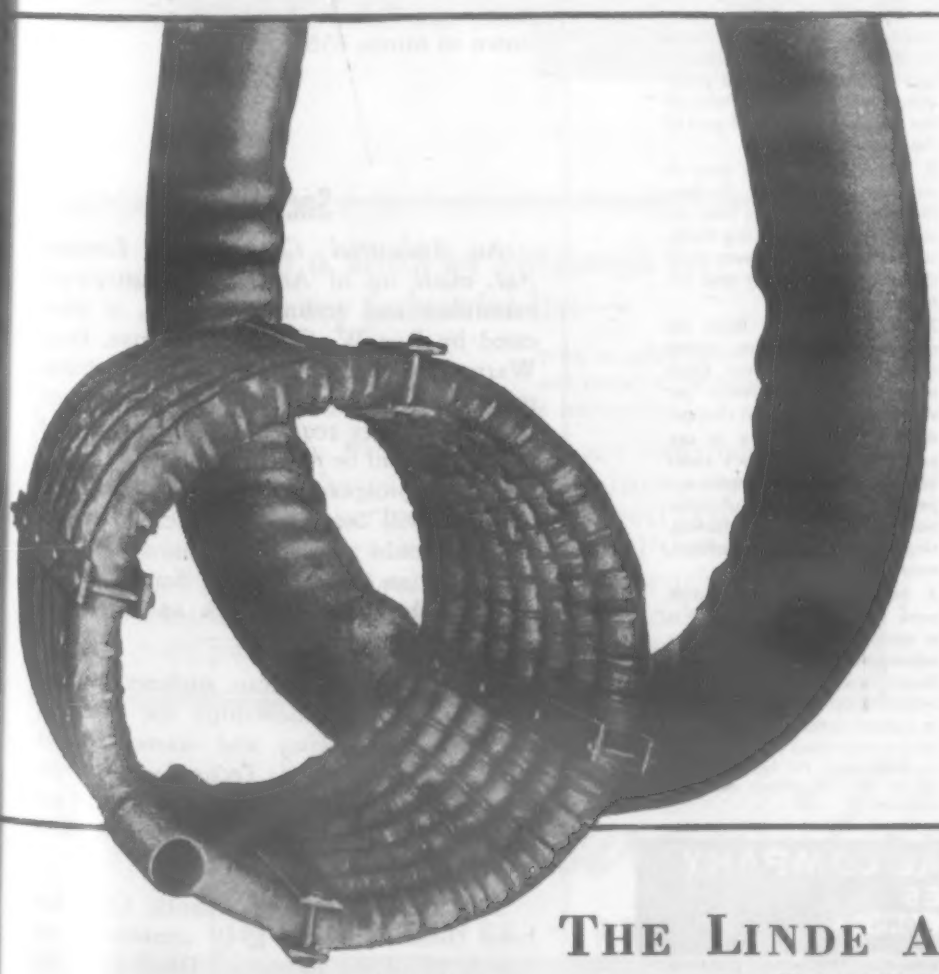
"Tailor-Made" Bends

Where compound bends are required in a continuous section of pipe, wrinkle-bends offer an ideal solution. Wrinkle-bends are leakproof, as strong as the pipe itself, require no maintenance, and are easy to insulate.



This short-radius wrinkle-bend joins a compressed air line to a reservoir. Wrinkle-bends can be made in brass, copper, aluminum, and steel pipe from 2 inches to 26 inches in diameter.

Pipe bends can be made right on the spot with the aid of an oxy-acetylene welding or heating blowpipe, a simple bending rig, and a few common tools. Wrinkle-bending does not reduce the thickness of pipe walls.



This condenser coil made from 2-inch stainless steel pipe has 350 wrinkle-bends.

There are many LINDE methods for forming, cutting, joining, and treating metals. LINDE engineering service is always on call to help customers with production, construction, and maintenance jobs. Just call the nearest LINDE office.

The word "Linde" is a registered trade-mark of The Linde Air Products Company.

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STEEL TUBING and BARS

PETERSON STEELS, INC. maintains the largest stock of high carbon-chrome (52100 type) steel, seamless tubing and round bars in the country. More than 200 sizes of tubes from .875" O.D. to 8.231" O.D. Bar stock from .171" round to 7.5" round.

Ring forgings also supplied quickly — any analysis, any size.

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Contains full information on all available sizes, finishes, etc. Write today, on your business letterhead, for your copy.

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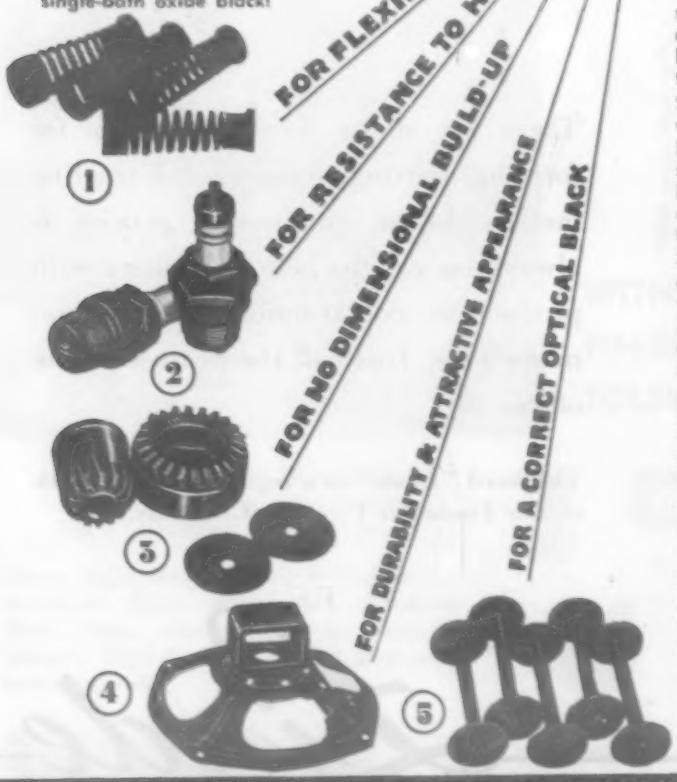
A New Horizon for Metal Finishing

BLACK MAGIC

Lift your product out of the "everyday" class by using BLACK MAGIC single-bath oxide black!



1. Black Magic, a rich, permanent black finish, is extremely flexible and can be applied to springs and similar wire products. It will not chip or flake off but becomes an integral part of the metal surface.

2. High resistance to heat is vital in spark plug finishes. Black Magic, a tough, heat resistant and rust inhibiting finish, is used regularly where heat changes are frequent and extreme.

3. As a protective finish for gears and small parts, where tolerances are important, Black Magic covers completely, yet effects no dimensional change.

4. Durable, attractive in appearance, Black Magic's smart black adds greatly to sales appeal and service life of radio parts. The deep-penetrating, single-bath oxide is economical, easy to use.

5. For exacting specification work in optics, Black Magic is a consistent performer. After subsequent processing, Black Magic makes possible the non-reflective, optical black required in optical instruments.

Write for the "Black Book" of details on Black Magic for iron and steel, copper and its alloys, zinc and cadmium.

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SILCO Glass-Base PROTECTIVE COATING
HEAT TREATING SALTS, CLEANERS, ETC.

News of...

ENGINEERS COMPANIES SOCIETIES

the new corporate name being *Whitney-Hanson Industries, Inc.*

The *Timken Roller Bearing Co.* has leased 50,000 sq. ft. of manufacturing space at 2300 Linden Ave., Zanesville, Ohio, in which to concentrate all Zanesville operations.

Fifty-eight employees of the *General Electric Co.* and its affiliates who did work of outstanding merit in 1946 and 1947 have received Charles A. Coffin awards, totaling $14,500 or $250 per person among those cited.

The *Chicago Metal Hose Corp.* has purchased the *Wheelock Mfg. Co.*, St. Johnsbury, Vt., the latter to be operated as the Wheelock Mfg. Div.

The name of the *Laclede-Christy Clay Products Co.* has been shortened to the Laclede-Christy Co.

Ten of the 13 new major facilities now under construction by *U. S. Steel Corp.* will begin operations this year.

The new pipe mill of the *Kaiser Steel Co.*, the first of its kind west of the Mississippi, is now in production and will turn out 90,000 tons of commercial and plumbing pipe annually. The pipe is produced by the Fretz-Moon process.

Arthur D. Little, Inc., Cambridge 42, Mass., recognize that one of their main accomplishments of 1947 was the bringing out of the Collins helium cryostat, which makes possible research at temperatures down to minus 456 F.

Societies

An *Industrial Council for European Aid*, made up of American industry's top executives and technical experts, is advocated by Roy W. Gifford, chairman, Borg-Warner International Corp. These technical men would be temporarily loaned to European companies requesting such help. The purpose would be to bring about a European society so prosperous and strong that Communism will lose its appeal. The undertaking would by no means be merely humanitarian. The United States has its own selfish interest in such an enterprise, Mr. Gifford maintains.

Three South American students will be awarded $1000 fellowships for graduate study in engineering and science at the Carnegie Institute of Technology for the year 1948-49. The one-year fellowships are awarded by the *Matthes Foundation*, New York.

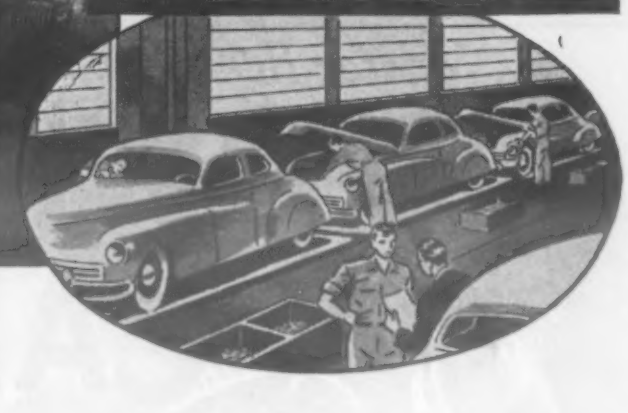
The Hotel Claridge, Atlantic City, has been chosen for the 1949 convention on March 15 of the *Industrial Diamond Assn.* At the 1948 convention, recently concluded,

This Beauty was once a rough, burr-ridden sheet of steel

This is the Pittsburgh Brush that did the job

This is how the Pittsburgh Brush does the job

This is what the Pittsburgh Brush helped to build



HERE'S WHAT HAPPENED:

Before this beauty rolled out of the factory, a large part of it had to be thoroughly brushed by one or more hardy Pittsburgh Power-Driven Brushes. Unbelievable that this gleaming body you see was once a burr-ridden, rough sheet of steel. Then Pittsburgh Brushes went to work to produce this smooth steel of beauty.

There's a Brush by Pittsburgh for *Every* Industrial Use—

GLASS	AUTOMOBILE	TIRE & RETREADING
STEEL	RUBBER	SHOE MANUFACTURING
PLASTICS	PAPER	& REPAIRING

In the complete Pittsburgh line are brushes of all types, including "Perfect Balance" sections, wheels and assemblies. Uni-fill scratch brushes as well as paint and other maintenance brushes. Consult the Pittsburgh engineering representative. He will gladly work with you in developing any type of power-driven brushes to meet your particular finishing specifications.

Use only Power-Driven Brushes By Pittsburgh—it pays

Specifically engineered to do your particular finishing requirements—the perfect balance of Pittsburgh's Brushes carefully controls distribution of the brushing stock. Perfect balance—maximum efficiency. You can depend on Brushes by Pittsburgh for top performance, enduring economy—and a minimum loss of time in change-overs.

Power Driven BRUSHES

BRUSHES · PAINT · GLASS · CHEMICALS · PLASTICS

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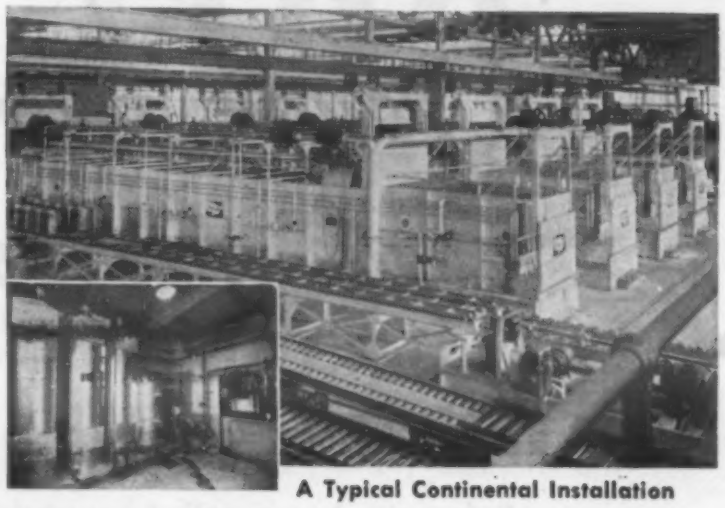
CONTINENTAL

Controlled Atmosphere Furnaces and Generators

Do You Want BETTER RESULTS?

Is it clean surfaces? Is it uniformity, or production capacity? Whatever your problem in processing with controlled atmospheres, Continental has the solution. Whether it involves a new heat-treating department, remodeling or modernizing an old one, or the addition of new specialized equipment, it is a Continental job. A quarter century of well-diversified experience in the heat-treating field with continuous specialized research and development in furnace design and application gives us the practical "know how" for the scientific approach to your problem.



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There are hundreds of modern designs of Continental furnaces, machines, and plants available for your preliminary planning. Write, and have us go over them with you. There is no obligation.

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News of...

ENGINEERS COMPANIES SOCIETIES

a spectacular feature was the shipment from England by the Diamond Trading Co., Ltd., of a 251-carat black diamond and a large crystallized diamond in the original matrix of blue-ground as found in South Africa. They were put aboard an overseas plane by the English screen star, Valerie Hobson, and relayed to Atlantic City from LaGuardia Field by helicopter and put on exhibition at Atlantic City.

The thirtieth annual meeting of the *American Zinc Institute* will be held at the Hotel Statler, St. Louis, April 15 and 16. Among the topics are: Metals and opportunities for industry in the farm market; steel industry in 1948; zinc smelting industry in 1948; outlook for zinc mining; and the world zinc situation.

The *Illinois Manufacturers' Assn.* is sponsoring a program of metal scrap collections in industrial plants. It includes the appointment of a plant salvage man with authority to collect scrap at each company. The association has issued a special bulletin on the subject which has been released to its 4500 members.

Eighty-five per cent of exhibit space in Philadelphia Convention Hall was under contract Feb. 1 for the castings industry that will participate in the 1948 Foundry Show of the *American Foundrymen's Assn.* May 3-7. The show will be held concurrently with the international technical society's 52nd annual meeting. Over 60 technical sessions will be held. Dr. Karl T. Compton, president, Massachusetts Institute of Technology, will be guest speaker at the annual banquet on "Team Work of Hand and Brain." Four groups of college engineering students have been admitted to AFA as student chapters. The units are in the University of Minnesota, School of Mines and Metallurgy of the University of Missouri, Ohio State University and Massachusetts Institute of Technology.

Membership in the *National Assn. of Corrosion Engineers* has doubled in the past year. Organized in 1943, it now has five regional areas. Each area has several sections located within it. This year's conference and exhibition was held April 5-8 at the Hotel Jefferson, St. Louis. The aims of the society are to study, control and pass along knowledge about corrosion.

The *Gray Iron Founders' Society* is now chiefly concerned with shortages of pig iron and scrap. R. L. Collier, executive vice president, believes that present pig iron scarcity may ease moderately after July 1. He says that the Department of Commerce has assured that no pig iron allocation programs affecting the foundry industry will be approved or put in operation without the society having an opportunity to be heard. He maintains that the pig iron producers can meet all demands without priorities or allocations.

LOOK AT THE DIFFERENCE!

ZINC PLATE
Unretouched photo of die casting plated in ordinary zinc bath.
. . . TURNS BRIGHT!
Identical plate exactly as it looked after immersion in Clear Dip.
. . . STAYS BRIGHT!
No appreciable change after 48 hours in standard salt spray booth.

. . . with a UNICHROME CLEAR DIP treatment

THESE THREE unretouched photographs show exactly what you can now do with zinc. That lustrous finish is yours—from *any* zinc plate—at trifling cost! It reflects a tremendous sales advantage. For Unichrome Clear Dip offers you not only an opportunity to cut finishing costs, but also a high quality finish that looks for all the world like chromium!

Can you depend on it to stand up? Take another look at the last photo for your answer. In salt spray for 48 hours—yet the finish is untouched! Its companion piece, plated with the same zinc but untreated, was thick with ugly white corrosion and badly discolored after the same exposure.

Unichrome Clear Dip accomplishes its work in a 5 to 20-second dipping. This chemical solution is easily controlled and cheaply replenished.

SEND FOR THIS BULLETIN

It will answer many of your technical questions and further explain how you can save money with this sparkling, sales-building finish.

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Chromium Plating • Porous Chromium • Unichrome* Copper
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WAX INJECTOR

. . . acclaimed as the finest machine of its kind. A versatile, precision-made unit, ideally adapted to wax injection into both rubber *and* metal molds . . . can be used as either a hydraulic or air-pressure operated unit.

The BARON Injector

Check these features against any other wax injector on the market:

- **Hydraulic or air-pressure operation**
- **Positive temperature control to within two degrees**
- **Positive pressure control to a fraction of a pound**
- **Complete control over the quantity of wax injected**
- **Complete visibility of temperature and pressure at all times**
- **Full two-quart capacity**
- **Designed for rapid wax pattern production**
- **Designed for simple fool-proof operation**
- **Available for operation on any type of electric current**

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Does manpower in your welding department mean numbers of men—or do you, more logically, measure manpower in terms of production?

Because welding is becoming increasingly important in every phase of production today, it is important that your welding be done faster, better and more economically. If weldors are using cranes or spending time propping up, turning over and flopping their weldments, they are interrupting production and increasing costs on every foot of welding.

Investigate the demonstrated advantages of C-F Hand or Power-operated welding Positioners and see how they can help your weldors produce better, faster and more economical welding. Weldors can swing weldments into any position because every weld is downhand, larger electrodes can be used with resulting savings in time and material. For production welding, C-F Power-operated Positioners are unequalled—equipped with either variable or constant speed table rotation and power tilt, C-F Positioners have been setting new standards in production welding in many varied industries. Write for Bulletin WP-22 and more details. Cullen-Friestedt Co., 1314 S. Kilbourn Ave., Chicago 23, Ill.

CULLEN-FRIESTEDT, CHICAGO 23, ILL.

C-F positioned welds mean better, more economical welds

News of...

ENGINEERS COMPANIES SOCIETIES

Stevens Institute of Technology has appointed eight engineers from industry as adjunct professors in five fields of graduate study at Stevens; also a visiting professor. The principal branches of engineering are represented. Metallurgy is well represented, with four assigned to the field.

Lucien Eaton, consulting engineer, Milton, Mass., has been made chairman of the mining standardization correlating committee, *American Standards Assn.* He has investigated mining problems of China, South America and Latin America.

The *Committee for Economic Development* has appointed nine additional members of its finance committee, they to join 34 others previously appointed to raise $800,000 in 1948. Among the new members are Thomas Drever, American Steel Foundries, Chicago, and George M. Humphrey, M. A. Hanna Co., Cleveland.

Wayne University, Detroit 1, is offering a new service, called "Audio-Visual Materials Consultation Bureau." Thus, companies and associations interested in making films, booklets, charts, or specimen products for educational purposes will be served. The bureau also offers assistance in development of films, film-strips, records, manuals, etc. for industrial training programs.

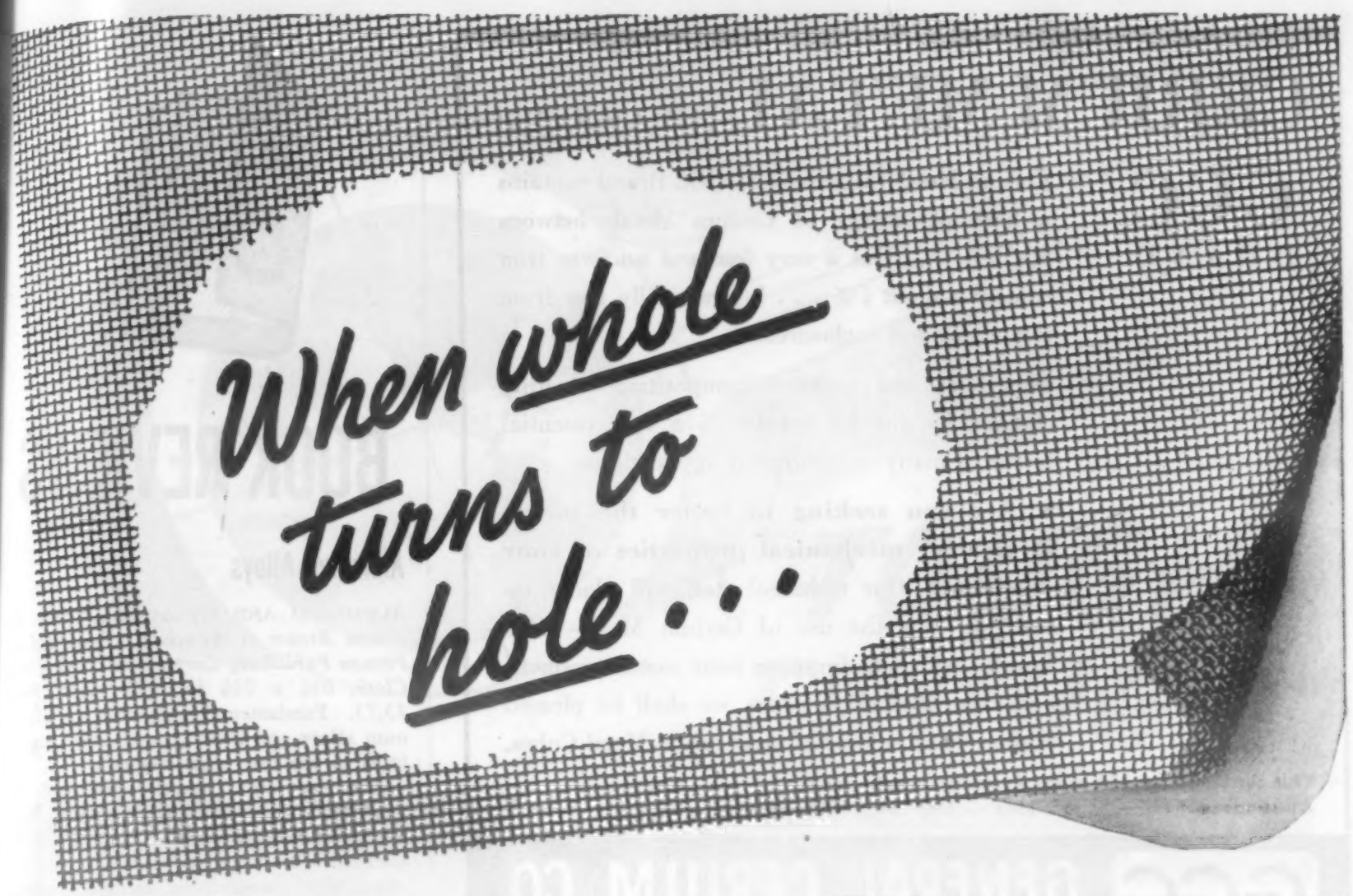
The *American Society of Mechanical Engineers* is awarding the John Fritz medal for scientific achievement to Dr. Theodore von Karman, aeronautical engineer, who aided materially in the development of jet propulsion, rockets, wind tunnels and supersonic equipment.

The Lehigh Valley section, *American Society for Metals,* has awarded the Bradley Stoughton plaque to B. H. De Long, vice president and technical director, Carpenter Steel Co. It is awarded to the metallurgist in the section "who has accomplished the most outstanding and generally useful metallurgical work."

The *American Society of Body Engineers, Inc.,* has elected as president Alfred H. Haberstump. At the last annual convention 38 manufacturers exhibited.

For the first time since 1941 *Modern Plastics* will revive the annual plastics competition. It is designed to bring into existence large numbers of new applications and designs for plastic products. There are 20 competition classifications and an award will be given in each group. Entries will be accepted from now to May 15, 1948. Details are obtainable from *Modern Plastics,* 122 E. 42 St., New York 17.

New York University's College of Engineering is conducting a management round table in work simplification at the Engineers' Club, 32 W. 40 St., New York, on ten consecutive Mondays, starting March 22. Among factors covered are: Overcoming resistance to change, selection of material, sound management-labor relations, etc.



Switch to Screen and Filter Cloth

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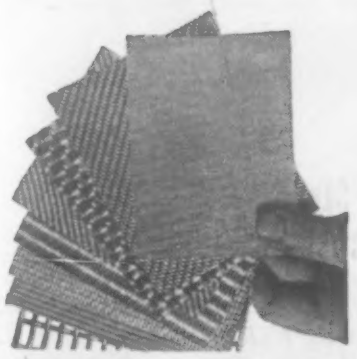

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Consult any quality weaver. He'll be glad to quote on the wire cloth you need to build extra life into your products.

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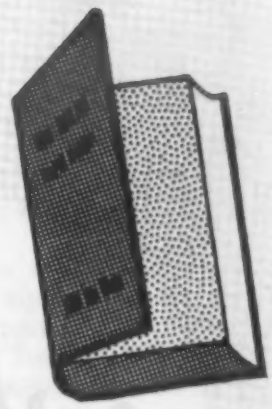


BOOK REVIEWS

Aluminun Alloys

ALUMINUM AND ITS APPLICATIONS. *By Hiram Brown & Associates. Published by Pitman Publishing Corp., New York, 1948. Cloth, 6¼ x 9¼ in., 338 pages. Price $5.75.* Fundamental properties of aluminum alloys and their general usage are set forth in the first eight chapters.

The next eight chapters deal with the practical applications of aluminum, written by specialists in the fields of aircraft assemblies, aircraft engines, aircraft castings, automotive manufacture, railroads, marine assemblies, electrical appliances and equipment, and the chemical industries. The present and future of aluminum are discussed in the last chapter.

The alloys are classified, with their distinctive properties and the most recent advances in fabrication stressed. The major alloys, fabricating methods (cast and wrought), finishing, testing, and heat treating are discussed. Well illustrated.

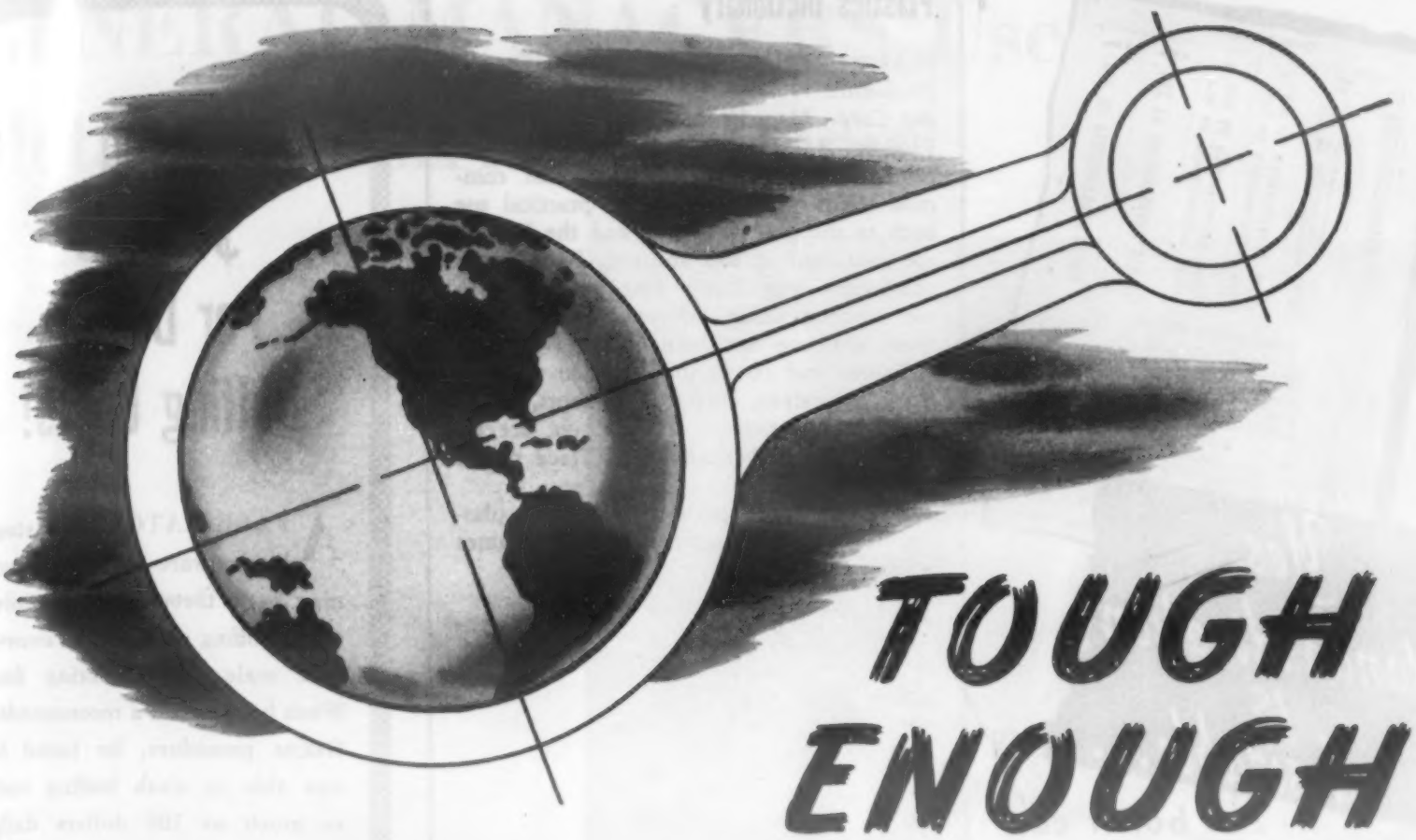
Tool Steels— Selections and Processing

TOOL STEEL SIMPLIFIED—SECOND EDITION. *By F. R. Palmer & G. V. Luerssen. Published by Carpenter Steel Co., Reading, Pa., 1948. Cloth, 6¼ x 9¼ in., 564 pages. Price $2.00.* Information on new and improved types of steels, types of heat treating equipment and methods of tool making is presented in this helpful "handbook of modern practice for the man who makes tools." Simplified methods for selecting and heat treating the proper steel to make any kind of tool are presented.

New material in this edition covers the latest advances in heat treating equipment, heat treating methods and testing, hardenability, and atmosphere control and quenching methods. Three new chapters deal with the Tool Steel Selector, Time Required to Heat Tool Steel, and High-Speed and Hot Work Steels.

The approach is intensely factual and of help to tool steel users wherever they buy their steel. A remarkable bargain at $2.00.

(More Reviews on page 168)



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"600" Metal is available in the form of rod, forgings and tubes. Unlike many other alloys, "600" Metal has a consistent, uniform grain structure in rod of large as well as small diameters.

Primarily where a bearing is subjected to a reciprocating motion, reduction in weight is essential to keep vibration at a minimum and to assure maximum efficiency. Because "600" Metal is stronger per unit of weight, parts can be made of equal strength out of "600" Metal with a REDUCTION OF 10% TO 35% IN THE WEIGHT OF THE FINISHED PART.

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Plastics Dictionary

PLASTICS DICTIONARY. *By Thomas A. Dickinson. Published by Pitman Publishing Corp., New York, 1948. Cloth, 6¼ x 9¼ in., 312 pages. Price $5.00.* Definitions of about 3,500 of the most common terms which will be of practical use both to the plastics expert and the layman are contained in this volume. Basic words and combining forms that will help in the understanding of many uncommon terms that are not defined are given.

Tables and charts that provide practical data on catalysts, chemical elements, fillers, pigments, plasticizers, solvents, etc. are included, in alphabetical order. Trade names are also covered.

Terminology applicable to British plastics, their manufacturers and trade names is included.

Other New Books

HANDBOOK FOR HORIZONTAL BORING, DRILLING AND MILLING MACHINES AND THEIR APPLICATIONS. *Published by Giddings & Lewis Machine Tool Co., Fond du Lac, Wis., 1948. Looseleaf binder 8½ x 11 in., 266 pages. Price $5.00.* Practical information about the modern horizontal boring machine and its versatility in performing standard and specialized work is covered. The book is divided into three sections: Machine Fundamentals, Basic Operations, and Work Methods. A fourth section, Outstanding Applications, is the place for information on the latest and most advanced machining techniques—these data sheets will be furnished each book owner without charge. Illustrated.

INDUSTRIAL WEIGHING. *By D. M. Considine. Published by Reinhold Publishing Corp., New York, 1948. Cloth, 6¾ x 9¾ in., 553 pages. Price $10.00.* A review of basic scale mechanics, design and construction of modern scales, and scale installation and maintenance is given in Part I. Part II is devoted to the application of scales. Contains chapters on individual industries, including one on mining, machinery and metal products, and others on rubber and plastics.

STRESS ANALYSIS AND DESIGN OF ELEMENTARY STRUCTURES—SECOND EDITION. *By J. H. Cissel. Published by John Wiley & Sons, Inc., New York, 1948. Cloth, 6 x 9¼ in., 419 pages. Price $5.00.* Basic principles and procedures relating to the stress analysis and design of simple structures are presented in this textbook.

SEVENTY-FIVE YEARS OF PROGRESS IN THE MINERAL INDUSTRY. *Edited by A. B. Parsons. Published by American Institute of Mining & Metallurgical Engineers, New York, 1947. Cloth, 6¾ x 9¼ in., 817 pages. Price $4.00 to members; $6.00 to non-members.* A series of articles, each dealing with progress during the 75-year period in one of the major branches of the production and use of mineral products and metals. Among the branches covered are Iron and Steel and Nonferrous Metallurgy. The Mineral Position of the United States, Iron Ore and the Steel Industry, The Role of the Engineer in the Development of Atomic Energy, Application of Atomic Energy to Industry, and Metals and Alloys of the Future, are among the subjects dealt with.

ENGINEERING LAMINATES. *By Walter C. Voss. Published by American Society for Testing Materials, Philadelphia, Pa., 1948. Heavy paper, 6 x 9¼ in., 34 pages. Price $1.00.* The 1947 Edgar Marburg Lecture of the A.S.T.M. is issued as a separate booklet. A review of some fundamentals, including atomic structure and bonds, crystal lattices, and plastics, is presented, followed by a section on adhesion. Some of the common laminates and methods of evaluating their properties are described.

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A FABRICATOR of steel kitchenware items was running parts through an expensive wheel buffing operation to remove heat scale and soldering flux. When he installed a recommended Oakite procedure, he found he was able to slash buffing costs as much as 100 dollars daily. Here's how:

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L. Rodenhausen is general manager of Rodenhausen Excelsior Wagon Works, Philadelphia, Pa., makers of auto bodies, hoists, etc.

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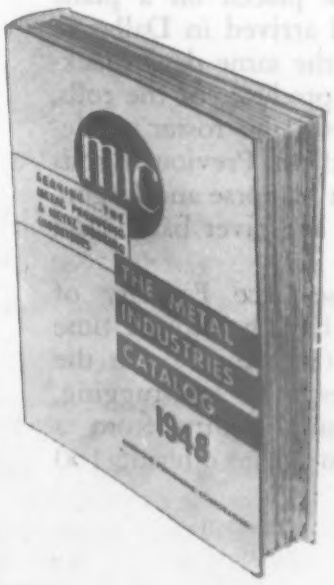
General managers, vice presidents, chief engineers, plant superintendents, tool supervisors, shop foremen, research managers, consultants, and on and on. So goes the list of men who turn to METAL INDUSTRIES CATALOG whenever the problem arises of getting some material and equipment. Why? Because MIC's variety of information offers quick answer to the problems peculiar to their plant operations. And because MIC's triple index (by company, product, and trade name) makes data easy to find. Next time you have some specifying to do, do it the convenient way. Look it up in MIC.

Put it to work . . . . when you need the FACTS!

METAL INDUSTRIES CATALOG



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The Last WORD

by T. C. DU MOND

Looking Backward

While most of us look forward to the days when war threats are gone, inflation an unpleasant memory, and everyone has plenty of everything (including money), one company has had to look backwards. This situation is somewhat akin to the "new look" which everyone knows is pretty old. Anyway, the American Nickeloid Co. started business just before the end of the last century with the intention of making sheet zinc electroplated with bright nickel. The business changed to include other base materials, until finally a large volume of plated steel was used. Now with steel in short supply, American Nickeloid is going back to its original product—nickel plated zinc, plus plated copper and brass.

Turnabout

The aircraft industry has, during its not too lengthy history, depended on the materials producing and fabricating industries to pull it out of difficult spots. Now the shoe is on the other foot. Two recent news items tell how planes have helped the plants. In Dallas a steel fabricating plant was about to lay off 275 workers because it needed steel rolls. Aircraft freight saved the day. At 3 a.m. one day two 600-lb. rolls were placed on a plane in Pittsburgh and arrived in Dallas in the afternoon of the same day. Mackintosh-Hemphill, producer of the rolls, finds this completes the roster of delivery media for them. Previously rolls have left the plant by horse and wagon, truck, freight car and river barge, and now planes.

In another case, Ace Foundry of Los Angeles was having a tough time getting pig iron (who else?). At the depth of their desperate hair-tugging, they got a routine inquiry from a salvage firm in San Diego offering 100 tons of pig iron which resulted from the dismantling of two World War I destroyers. Knowing that other foundries would be bidding on the coveted iron, Ace officials hopped into their own company plane and within 2 hours had bought the 400 tons of pig.

Who Got Stung?

We imagine the large steel companies feel like the small boy who poked a stick in a hornet's nest. The recent price advance of semi-finished goods brought down a horde of congressional and Department of Justice investigators that is still buzzing about. We sympathize with the steel companies, but agree with most everyone else that the timing of this price rise —as insignificant as it might be—was very poor. We had rosy visions of inflation being halted, at about the time this furore came, and our dollars rising in value to at least 75¢ each. Even if the price rise does not ripple through industry, the psychological effect of the whole mess is bad.

Editors' Dilemma

In a February article on Trodaloys (A New Group of Strong, Conductive Copper Alloys) the statement was made that these alloys were the equivalent of beryllium copper in proportional limit and superior in some other respects. The issue had hardly settled on the desks of our readers when we got several communications from beryllium copper people taking issue with the statement. The gist of the matter is that 2% beryllium copper has a proportional limit, varying up to 30% greater than Trodaloy I, depending upon the condition of the material. The dilemma arises from the fact that the article was reviewed by at least one beryllium copper authority who failed to point out any variations from accepted fact.

Direct Action

As has been the case with many companies, Carnegie-Illinois Steel Corp. found that one of the reasons it couldn't get enough help was because of the housing shortage. To overcome this situation, Carnegie-Illinois is building 38 housing units to accommodate 456 unmarried male employees. The dormitories are being built on a lot adjacent to the corporation's Gary works.

Here's Who

The "File Facts" in our March issue should prove useful in comparing the quantity of any given materials obtainable for one dollar. Compilation of the two "File Facts" was done by Gerald C. Johnson Associates, product design and development engineers, of New York City. The material is copyrighted by that firm and was published by MATERIALS & METHODS with their permission.

Scrap Source

We've become very scrap conscious during this period of shortage. If we're observed walking around with our head down, it's not because we're weary or bashful. We're looking for scrap. This might be a good time for traction companies and municipalities to tear up abandoned street car tracks. There must be thousands of tons of high grade scrap in the streets of Manhattan alone. Add to this the thousands of miles of buried track in other cities throughout the nation and we would have sufficient scrap to offset the shortage. At current prices, the recovered steel would go far towards paying the costs of resurfacing the streets.

The Right Metal in the Wrong Place

Recently the Aluminum Co. of America received an award for the best corporation annual report. The shine of this particular honor was tarnished somewhat by the fact that the token of the honor was a *bronze* Oscar of Industry.

Talk About Readership

One of our Swedish friends writes to report that MATERIALS & METHODS is well used in the plant in which he is employed. During 1947 the one issue received was studied by at least 22 of the company's engineers; this year M&M will be routed to no less than 91.